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•

TABLE OF CONTENTS

Chairman Morning Session
R. H. Hilgeman
Horticulturist
University of Arizona
Tempe, Arizona

Chairman Afternoon Session
C. W. Van Horn
Citrus Care, Inc.
Yuma, Arizona

STATUS OF THE DATE INDUSTRY IN THE SALT RIVER VALLEY

By R. H. HILGEMAN

Horticulturist
University of Arizona

Chairman — Morning Session

Members of the Coachella Valley Date Institute:

It was with great pleasure that I accepted your invitation to act as your chairman this morning. I always enjoy coming to the Coachella Valley and having an opportunity to visit briefly with my old friends over here. During the 36 years that I have been associated with the Date Industry in Arizona, I have seen it gradually rise from a few struggling growers in the '30's to a prosperous industry during and after the war and then gradually decrease to less than 75 acres, which scarcely can be called an industry. This has happened, despite some of the finest leadership any industry could have.

Date production in the Phoenix, Arizona area has never been large. Most of the commercial plantings were made between 1920 and 1930 and amounted to about 500 acres. At this time the experimental planting at the University of Arizona Date Garden had demonstrated that there was not an outstanding variety suited for the Phoenix area. Consequently, many different varieties were planted. These included Hayany, Khadrawy, Maktoom, Iteema, Sayer and Deglet Noor. By the mid-30's, when these gardens began to produce fruit, it was quickly found that each variety presented a different problem. It was difficult to standardize picking, curing, hydration, and dehydration programs. Two attempts to develop cooperative packing and marketing facilities were unsuccessful chiefly because of the many different varieties and the small volume of each.

Most of the growers built small packing houses and developed their own markets. Marketing developed along two lines. A medium quality product was sold through the local grocery and specialty stores. A high quality, fancy pack was sold directly by growers to consumers as Christmas gift packages both in Phoenix and through mail orders.

During and immediately after World War II, date prices were high and all gardens were well cared for and prosperous. After the war years, when prices resumed a normal level, costs remained high. Also, in 1950 an extremely heavy rain caused almost complete loss of the crop. This occurred at a critical time.

The large influx of people into the Salt River Valley was causing rapid subdivision of citrus and other farming areas. The financial losses of the growers accelerated the subdivision of date gardens. Since 1950, most of the date gardens have been subdivided. At present there are only a few date growers left in the Valley. These growers rely chiefly on gift package sales and mail order business.

An interesting development has evolved in the past 10 years, which is illustrated by the program of one grower. This man had 10 acres of Khadrawy dates. He sold his garden for subdivision but retained his packing house facilities. He now has made arrangements with some of the home owners in the subdivided gardens to harvest their fruit. Under his arrangement, he removes leaves, dethorns the trees, pollinates, thins, bags the bunches and harvest the crop. The owners of the trees receive a nominal sum for the fruit. He informed me that he harvests about 150,000 pounds of fruit each year under this program. Thus, even though a date garden was subdivided, it still remains in production. The number of people who are willing to handle fruit in this way are limited and I suspect it will gradually stop as palms become taller and people trained in date culture retire.

GROWTH OF YOUNG DATE PALMS IN RELATION TO SOIL SALINITY AND CHLORIDE CONTENT OF THE PINNAE

By J. R. FURR, C. L. REAM and A. L. BALLARD

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Introduction

Though the date, *Phoenix dactylifera* L., has long been grown in saline soils and is highly salt tolerant, our knowledge of the influence of excess salt on its growth and yield is based largely upon observations of commercial plantings in saline soils. We have little experimental data on the effect of salt concentration of the soil on salt uptake and on vegetative growth of the date. The meager literature relative to the influence of soil salinity on the date was reviewed by Furr and Armstrong (3).

This paper reports the results of an experiment made to determine the effect of several levels of soil salinity on chloride content of the pinnae and on growth of the leaves of two varieties of date, 'Medjool' and 'Deglet Noor'.

Materials and Methods

The field plot techniques and methods of estimating salts in water and soils used in this work were those developed by the United States Salinity Laboratory Staff (4). Ten rooted offshoots, 5 Deglet Noor taken direcly from parent palms and 5 Medjool nursery offshoots, were planted in each of 5 plots consisting of basins 21 x 15 feet, formed by throwing up borders of soil 1 foot high around each plot. The offshoots in each plot were planted 3 feet apart in rows 2 feet apart and were irrigated with Colorado River water containing about 149 parts per million (ppm) of chloride and about 700 ppm of total soluble salts for a year before the salt treatments started on July 21, 1964. A buffer strip 8 feet wide was left between basins. Midway of the buffer strips and around each end of the plots, narrow trenches 3 feet deep were dug and kept open as barriers to growth of roots from the salt plots into unsalinized soil. At the start of salt treatments highly saline water was applied to salinize the soil below the bottoms of the trenches. As a result of a break in the border of the control plot on October 6, 1964, some soil below the ditches was leached enough to allow some roots to grow under the ditches in the spring of 1965. After additional breaks in the control border on June 1 and 8, 1965, the ditches were deepened 1 foot. A few roots that had grown under the ditches were cut, and a heavy application of salt was made in the ditches and leached into the soil underneath.

The plots were on a calcareous, stratified soil of Indio very fine sandy loam, underlain by grey, very fine sand several feet deep. Below this fine sand for about 20 feet were alternating layers of silt and sand or sandy silt. The upper 4 or 5 feet of

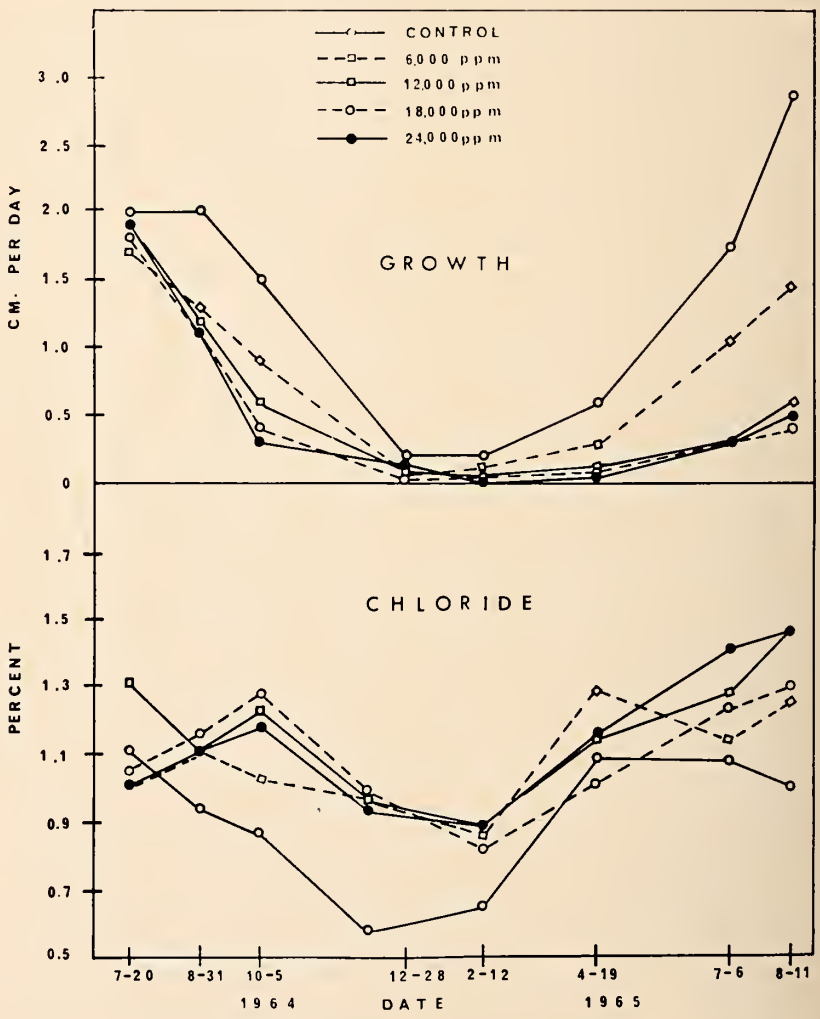

Figure 1. Growth rate in centimeters per day of 'Medjool' leaves in relation to chloride content of pinnae.

very fine sandy loam drained to the estimated field capacity of 20 to 25% in about 1 week.

From the start of salt treatments on July 21, 1964, until the end of the experiment on August 11, 1965, the control plot was irrigated with well water containing only 11 ppm of chloride. Since our object was to determine the effect of salinity on growth, well water rather than canal water was used on the control plot to reduce soil salinity in that plot to the lowest level possible. The salinized irrigation water was prepared by pumping Colorado River water from the Coachella Valley Branch of the All American Canal into two 500-gallon tanks and adding sodium chloride and calcium chloride in equivalent amounts to make the several concentrations needed. The estimated weights of salts needed were added to a measured volume of water in a tank, but since moisture content and purity of the salts varied slightly, the approximate salt concentration was determined from electrical conductivity measurements made on samples of water taken from the tanks and adjustments in weights of salts were made to obtain water of approximately the desired salt concentration. About 2.5 inches of water was pumped onto a plot at each irrigation. The approximate salt content, the electrical conductivity (EC X 10^3 at 25 C), and the estimated osmotic pressure of the water applied to the different plots are listed in Table 1. The plots were watered each week in warm weather (April to mid-November) and every 2 or 3 weeks the remainder of the year. Enough water was applied at each irrigation to cause some leaching and thus to maintain a relatively stable salt content of the soil in the root zone of the palms. The soil of each plot was sampled to a depth of 4 feet at 1-foot intervals, usually just before watering. The conductivity of the saturation extract (ECe X 10^3 at 25 C) of the soil sample was determined (4) as an indication of salt concentration of the soil water just before irrigating.

The rate of growth of a young leaf on each palm was determined from measurements of leaf elongation made weekly in warm weather and about monthly in winter (1). For chemical analysis, pinna samples from young, mature leaves were taken at intervals of 1 or 2 months. Chlorides were determined by electrometric titration and sodium by flame photometry as percentages of dry weight of the tissue.

At the start of salt treatments, to bring the salt concentration up to the assigned values gradually, the plots were watered at intervals of 1 to 3 days. The salt concentration of water applied to plots was increased by 6000 ppm per application until all plots were receiving water of the assigned salt concentration. The frequent watering at the start of the experiment soon salinized the soil throughout the root zone.

Table 1. Approximate salt content[1], electrical conductivity (EC X 10^3 at 25 C), and estimated osmotic pressure[2] of irrigation water applied to date plots.

Treatment: Approximate Salt content	Plot Designation	Electrical Conductivity (EC X 10^3 at 25 C)	Estimated osmotic pressure
(ppm)		(mmhos/cm)	(atmospheres)
253	Control	0.35	1
6,000	6M	11.0	3.7
12,000	12M	20.0	7.1
18,000	18M	29.5	9.8
24,000	24M	38.0	14.2

[1]Derived from conductivity (EC X 10^3 at 25 C) values and curves of Fig. 3 of U.S.D.A. Handbook No. 60 (4).

[2]Derived from conductivity (EC X 10^3 at 25 C) values and curves of Fig. 5 of U.S.D.A. Handbook No. 60 (4).

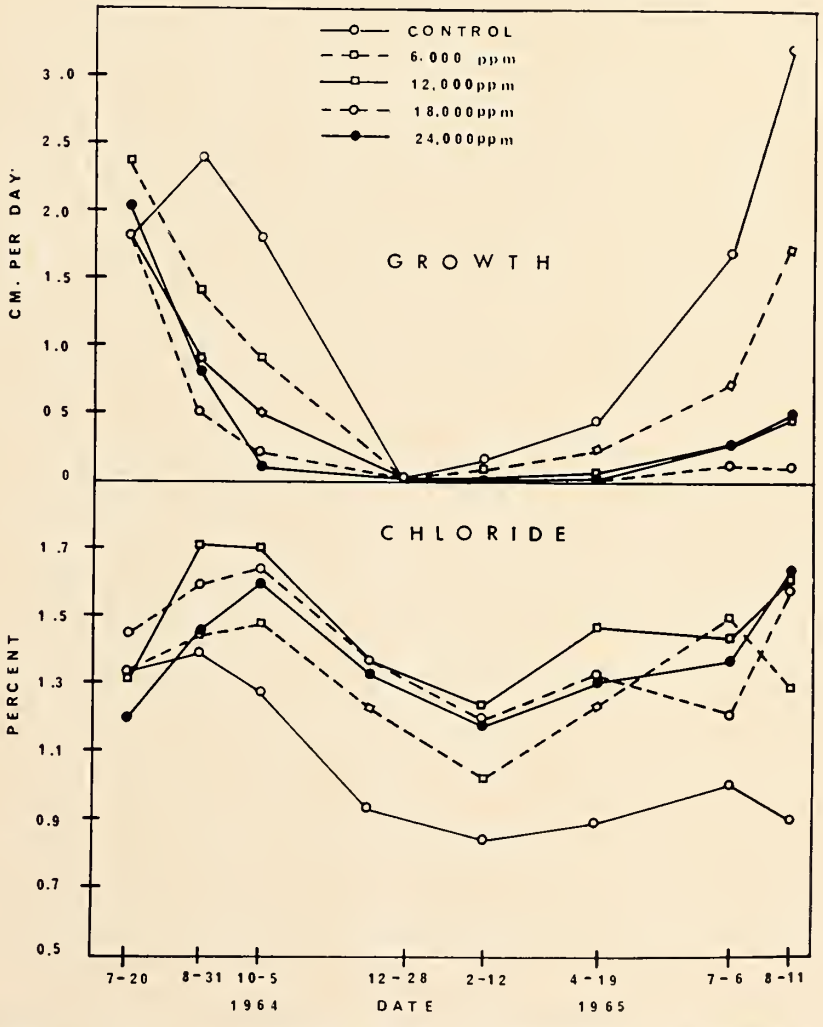

Figure 2. Growth rate in centimeters per day of 'Deglet Noor' leaves in relation to chloride content of pinnae.

Table. 2 Average electrical conductivity of the saturation extract (ECe X 10^3 at 25 C) in millimhos per centimeter of soil samples taken just before each watering.

Treatment: Salt Content of Water	Plot	Soil depths-feet			
		0-1	1-2	2-3	3-4
(ppm)		(mmhos)	(mmhos)	(mmhos)	(mmhos)
253	Control	1.1	1.2	1.3	1.9
6,000	6M	26.6	19.3	16.1	10.3
12,000	12M	35.6	31.2	24.9	26.2
18,000	18M	53.9	40.0	31.1	34.8
24,000	24M	50.5	51.2	43.5	44.1

Results

The conductivity of the saturation extract (ECe X 10^3 at 25 C) of soil samples from a given plot and depth varied appreciably from week to week, but the average values for the period of the experiment (Table 2) reflect the differences in salt concentration of water applied to the different plots. These average ECe values also represent the average high values attained during the wetting and drying cycles at the different depths. Some leaching was accomplished at each irrigation, but the variation in the ECe values with depth of soil shows that the salt concentration of the soil water increased during the intervals between irrigations as a result of water extraction by the palms and evaporation from the soil surface. Just after watering, the concentration of soluble salts in the top 1 or 2 feet of soil was probably nearly the same as that of the irrigation water applied. Since the saturation percentage of the soil is approximately twice the field capacity and since the moisture content of the soil below the top foot in the salt plots was usually near field capacity when irrigation water was applied, the concentration of soluble salts in the soil water just before irrigation was probably about twice that indicated by the ECe values (4).

The average chloride content of the pinna samples taken July 20, 1964, just before salt treatments began (Figs. 1 and 2) was, in the Medjool pinnae, about 1 to 1.3% of the dry weight and, in the Deglet Noor pinnae, about 1.2 to 1.4%. The chloride content of pinnae from the Medjool and Deglet Noor controls decreased from the July or August samplings to those taken in December or February, presumably in part in response to the use of water low in Cl on the control plot (Figs. 1 & 2). The Cl content of pinna samples of both varieties in all the salt plots, however, also decreased between October 5 and December 7. This decrease in Cl content of pinnae seemed to be associated with the decreased growth of the palms. The Cl content of the pinna samples from both varieties, including the controls, increased during the spring and summer of 1965. This increase was associated with an increase in both air temperature and growth rate of the leaves. The rather sharp rise in Cl content of the pinna samples from the Medjool control palms in the spring of 1965 may have resulted, in part at least, from the growth of a few roots under the ditch next to plot 18M and into soil of high salt content.

The growth rates of the leaves of palms of both varieties in all the salt plots declined sharply from the start of the salt treatments until December and increased again in the spring and summer of 1965 until August 11, when the experiment was terminated. Except for a higher growth rate, the growth curve of control palms was similar in pattern to that of the treated palms. The growth rate of all palms seemed to be greatly influenced by seasonal factors as well as by soil salinity. By August 1965 the growth rate of leaves on the control palms of both varieties exceeded the maximum rate attained in the preceding summer. The improvement in growth rate of the controls probably resulted from increased vigor as the plants developed larger root systems and greater leaf surface than they had in the previous season. There was not, however, a corresponding increase in growth of the palms under salt treatment.

The chloride contents of the pinna samples were not closely related to the amount of chlorides in the irrigation water. Chlorides in the pinna samples from palms in plot 6M were not always lower than those from palms in plots 18M or 24M. Except in the pinna samples taken before treatments were started and in those from Medjool palms on April 19, 1965, however, samples from the controls were lower in chloride than those from palms irrigated with saline water.

The sodium percentages of the pinna samples taken at the end of the experiment, August 11, 1965, seemed unrelated to salt treatment and, in most cases, were so low that it seems unlikely that growth rate of leaves was much depressed by their sodium content (Table 3). The highest Na percentage was found in a sample from old leaves of Deglet Noor from plot 6M. The leaves from which this sample was taken may have accumulated salt from the ditches. After the ditches between plots were deepened and highly saline water was applied to the soil at the bottoms of the ditches on June 16, 1965, several leaves of a few palms were severely injured, apparently as a result of intake of highly saline water through cut or otherwise severely injured roots. The injury appeared 2 or 3 days after the salt was applied in the ditches and was confined to a few leaves per plant, or in one palm to several leaves and to 2 young offshoots. The injured leaves showed severe salt burn and part or all of their pinnae were killed. The palms injured were as follows: plot 6M, 2 Deglet Noor; plot 12M, 1 Medjool; plot 18M, 3 Medjool; plot 24M, 1 Medjool. Injury to these palms did not noticeably reduce the rate of growth of uninjured leaves.

At the termination of the experiment, August 11, 1965, the palms were dug up and the roots examined. No dead roots were found in the basins and no injury to roots was evident. In the top foot of soil, however, roots were sparse in the salt

Table 3. Sodium content in percentage of dry weight of pinnae of Medjool and Deglet Noor palms in relation to salt treatment.[1]

Treatment: Salt content of water	Plot	Medjool		Deglet Noor	
		Young pinnae	Old pinnae	Young pinnae	Old pinnae
(ppm)		(%)	(%)	(%)	(%)
253	Control	0.02	0.02	0.02	0.02
6,000	6M	0.02	0.06	0.13	0.51
12,000	12M	0.04	0.10	0.03	0.04
18,000	18M	0.04	0.15	0.03	0.04
24,000	24M	0.04	0.08	0.03	0.03

[1]Samples taken at termination of experiment, Aug. 11, 1965.

plots and numerous in the control plot. In plot 24M the tips of large roots were brown and obviously not growing, but in plots 6M, 12M, and control many roots with white tips, indicating recent growth, were found.

The appearance of palms in the different plots did not differ greatly. Some leaf burn was obviously attributable to salt injury, but pinnae on old leaves of control palms showed bronzing and dieback indistinguishable from salt injury. With increasing salinity of the irrigation water, however, burning and dieback of pinnae on the palms in salt plots increased noticeably. The oldest leaves showed the most salt injury. Pinnae started dying back usually at the distal end of the leaves, and the pinnae also usually burned first at the tips, though sometimes the mid-portion on one side of the midrib of pinnae burned first.

The average daily growth rates of leaves during the entire 380 days of the experiment and those during the last 56 days indicate the relative effect of the different salt treatments on vegetative growth of the two date varieties (Table 4). The growth rates during the final 8 weeks were calculated separately from those of the entire period of experiment because presumably the plants in the final 8 weeks were fully at equilibrium with their environment and were subjected to high daily temperatures and should by then have shown the full effects of the salt treatments.

The average growth rate of the Deglet Noor palms in plot 18M was lower than that in 24M. We are not certain of the reason for this, but it was probably caused by soil variability. The irrigation water stood on the surface of soil in plot 18M a little longer than in 24M, and some soil samples from 18M had higher salt content than samples from the same depth in plot 24M. Except for the palms in plot 18M, however, the average daily rates of leaf growth decreased as soil salinity increased.

Rates of leaf growth of trees in the salt plots, expressed as percentages of the growth rate of the controls of the same variety, show clearly the relative effect of the salt treatments on leaf growth (Table 4). The growth of trees, especially Deglet Noor during the last 56 days of the test, was severely depressed in plot 18M, probably as a result of somewhat slow water penetration in that plot and excessive accumulation of salt in the top foot of soil. In plot 6M the growth rate was reduced to roughly 50% of that of the control. The next increment of 6000 ppm of salt depressed growth of trees in plot 12M to about half that of trees in plot 6M, although the next increment of 12,000 ppm of salt reduced the growth rate of trees in plot 24M not to one-half but to roughly ¾ of that of trees in plot 12M.

The general appearance and relative size of typical palms of each variety from each plot are shown by photographs taken at the termination of the experiment (Fig. 3). The size of palm was closely related to the concentration of salt in the water applied except for the Deglet Noor from plot 18M, the small size of which reflects the excessive accumulation of salt in the top foot of soil in that plot.

Discussion and Conclusions

Though ECe values in Table 1 are averages of samples taken at the dry end of the wetting-drying cycles, they do not fully represent the extreme concentrations of salt to which the date roots were sometimes subjected. In the upper 2 feet of soil of plots 18M and 24M, the ECe values indicated that salt concentration of the soil water often exceeded that of sea water, 35,000 ppm. Date roots are apparently highly resistant to injury from short periods of such high salt concentrations. At the termination of the experiment extensive examination of the roots revealed no evidence of injury from salinity, and although most of the roots in the upper 2 feet of soil in plots that received water with 18,000 or 24,000 ppm of salt were not growing, they

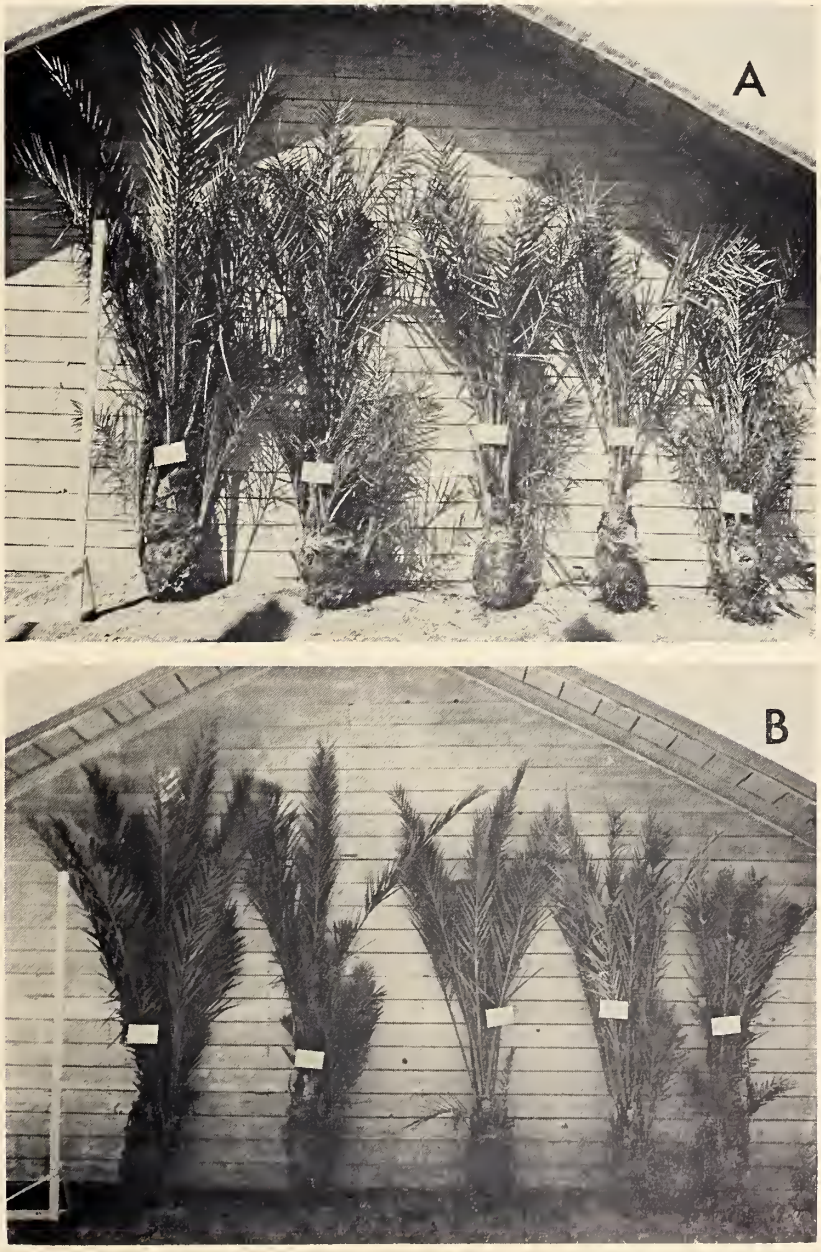

Figure 3. Representative palms from control plots and each salt plot at the termination of the experiment, August 11, 1965. A. Delget Noor, left to right: Control, 6M, 12M, 18M, 24M. B. Medjool, left to right: Control, 6M, 12M, 18M, 24M.

Table 4. Average leaf growth rate of Medjool and Deglet Noor palms under salt treatment as millimeters per day and as percentage of the controls.

Treatment: Salt content of water	Plot	Period: July 21, 1964 to August 11, 1965 (380 days)		Period: June 16 to August 11, 1965 (56 days)	
		Medjool	Deglet Noor	Medjool	Deglet Noor
(ppm)		(mm/day)	(mm/day)	(mm/day)	(mm/day)
253	Control	107	115	211	225
6,000	6M	64	65	114	103
12,000	12M	42	32	48	38
18,000	18M	35	16	32	15
24,000	24M	31	20	35	35
		(% of control)	(% of control)	(% of control)	(% of control)
253	Control	100.0	100.0	100.0	100.0
6,000	6M	59.8	56.5	54.0	45.8
12,000	12M	39.3	27.8	22.7	16.9
18,000	18M	32.7	13.9	15.2	6.7
24,000	24M	29.0	17.4	16.6	15.6

were apparently healthy and were presumably absorbing water whenever the salt concentration was low enough to make it possible.

The Cl content of the Deglet Noor pinnae was slightly higher than that of the Medjool, and in comparison with their respective controls the growth rate of Deglet Noor leaves was lower than that of Medjool. These relationships indicate that Medjool is somewhat more salt tolerant than Deglet Noor.

In the pinnae of both varieties chlorides decreased slightly in winter. We do not have a satisfactory explanation of this, though dry weight of pinnae may have increased and an apparent decrease in Cl resulted, or there may have been some migration of Cl out of the pinnae.

At the start of the salt treatments the chloride content of the pinnae samples ranged from about 1% to 1.5%. This accumulation occurred while the palms were irrigated with canal water containing about 150 ppm of chlorides. The remarkable ability of the date palm to exclude salts is shown by the very small increase in Cl content of the pinnae of palms irrigated for over a year with water containing 24,000 ppm of chloride salts. In fact the amounts of chloride and sodium that accumulated in the pinnae were not closely related to the amounts in the irrigation water or in the soil. Pinnae from palms irrigated with water containing 24,000 ppm of salt contained less than 0.5% more chloride than those irrigated with water containing only 6,000 ppm of salt. That toxic effects resulting from differences of only 0.3% or 0.4% of Cl in the leaves would produce the striking differences in leaf growth that occurred on palms under the different treatments seems unlikely. It is more probable that the salt reduced water absorption through osmotic or other effects and that this was the principal cause of the progressive decrease in leaf growth rate as soil salinity increased. Solutions that contained 6,000, 12,000, 18,000, and 24,000 ppm of salts would produce osmotic pressures, respectively, of about 4.3, 8.0, 12.5, and 16.4 atmospheres (4).

Since a soil moisture tension equivalent to 15 atmospheres is considered to be the approximate wilting point of soils, it is to be expected that growth will be progressively reduced as the osmotic pressure of the soil solution is increased from 4.3 to 16.4 atmospheres. That the date palm can make the internal adjustment in osmotic pressure of its cells necessary to continue growth even at a low rate in a soil solution of over 16 atmospheres osmotic pressure shows that it has developed remarkable salt tolerance. Eaton (2) first pointed out that as plants are subjected to increasing salinity, injury does not become pronounced at some abrupt point, but that above some minimum concentration each successive unit of salt tends to depress growth less than the preceding unit. The results of this experiment agree with the above principle if we disregard the anomalous results obtained from plot 18M. Although the date can tolerate extended periods of high soil salinity, it will not make satisfactory growth in highly saline soil. In this test the growth in the plot irrigated with water containing 6,000 ppm of salt was reduced to approximately 50% of that of the control. However, the trees were irrigated each week in warm weather to avoid much concentration of the soil solution. This might not be feasible in commercial practice. The 50% reduction in growth makes it unlikely that dates could be grown profitably in this country under present economic conditions with water containing even the lowest concentration of salt used in these tests, 6,000 ppm. These tests showed, however that date palms are highly resistant to injury from much higher concentrations of salt in the soil than permit good growth.

Abstract

Young date palms of 2 varieties, 'Medjool' and 'Deglet Noor', were grown for a year in field plots irrigated with Colorado River water and then different plots—control, 6M, 12M, 18M, 24M,—for 380 days were given treatments consisting, respectively, of water containing concentrations of chloride salts in ppm, as follows: well water control, 11; 6M, 6,000; 12M, 12,000; 18M, 18,000; 24M, 24,000. Plots were irrigated frequently, but the average electrical conductivity values of the saturation extract (ECe X 10^3 at 25 C) of samples of the second foot of soil taken just before each irrigation throughout the test were: control, 1.2; 6M, 19.3; 12M, 31.2; 18M, 40; 24M, 51.2. The increase of up to 0.5% chlorides in dry pinnae tissue from the different plots was not closely related to soil salinity. The sodium content of pinnae at the end of the test was relatively low and showed little relation to salinity treatment. The Medjool was slightly more salt tolerant than Deglet Noor. The date roots were apparently able to absorb water from the saline soil and exclude most of the salt. Growth rates of young leaves on palms in salt plots were reduced as soil salinity increased. During the last 8 weeks of the test the average growth rates of leaves as percentages of the controls were approximately as follows: 6M, 50; 12M, 20; 18M, 15; 24M, 16. The date palms were resistant to injury from high concentrations of chlorides for relatively long periods, but did not grow well at concentrations above 6,000 ppm.

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DATE PALM INSECT AND MITE PESTS IN THE UNITED STATES

By H. S. ELMER

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The need for date pest studies and control began in the United States in 1890 with the first successful importation of dates into the country. The original imported date palms and many brought in later were infested with the parlatoria date scale, *Parlatoria blanchardi* (Targ.). Boyden in 1961 summarized the work done in eradicating this scale insect. A number of other insects and mites are injurious to either date palms or date fruit. Stickney et al. (1950) grouped these pests as species attacking the palm, those found chiefly on or in the developing fruit, those feeding on dates decaying on the ground, and those attacking stored dates.

This discussion, however, will consider mainly the pests of most concern to the date growers during the past 20 years with only a brief reference to those insects that are of little or no economic importance at the present time. Methods of control are discussed separately for each pest except for a section, in conclusion, on packing house pest control procedures. The following table lists the major pests in approximate rank of economic importance along with most of the minor pests listed alphabetically by common name.

Major Pests

Banks grass mite[a], *Oligonychus pratensis* (Banks)

Fabricius Nitidulid beetles

1) Corn sap beetle[a], *Carpophilus dimidiatus (Fabricius)*
2) Dried-fruit beetle[a], *Carpophilus hemipterus* (Linnaeus)
3) Yellowish nitidulid, *Haptoncus luteolus* (Erichson)
4) Pineapple beetle *Urophorus humeralis* (Fabricius)

Raisin moth[a], *Ephestia figulilella* Gregson

Indian-meal moth[a], *Plodia interpunctella* (Hübner)

Apache cicada, *Diceroprocta apache* Davis

a Officially recognized common nome by the Committee on Common Nomes of Insects of the Entomologicol Society of America. The other common nomes ore generolly occepted in United Stotes literoture by those concerned.

Minor Pests

Bees, hornets, and wasps

Datebug[a], *Asarcopus palmarum* Horvath

Date stone beetle, *Coccotrypes dortyliperda* (Fabricius)

European grain moth[a], *Nemapogon granella* (Linnaeus)

Fig beetle, *Cotinis texana* Casey

Giant palm borer, *Dinapate wrightii* Horn

Hairy fungus beetle, *Typhaea stercorea* (Linnaeus)

Merchant grain beetle, *Oryzaephilus mercator* (Fauvel)

Mites (in stored dates only)

Navel orangeworm[a], *Paramyelois transitella* (Walker)

Palm rhinoceros beetle, *Strategus julianus* Burmeister

Red date scale[a], *Phoenicococcus marlatti* Cockerell

Rusty grain beetle[a], *Cryptolestes ferrugineus* (Stephens)

Saw-toothed grain beetle[a], *Oryzaephilus surinamensis* (Linnaeus)

Vinegar flies, *Drosophila* genus

Western leaf-footed bug, *Leptoglossus zonatus* (Dallas)

The parlatoria date scale, *Parlatoria blanchardi* (Targ.), is not included in Table 1 because it was apparently successfully eradicated by 1936 in the United States (Boyden 1941). However, if this scale should ever become reestablished, it would have to be considered one of the most economically important pests on dates.

MAJOR PESTS

Banks Grass Mite

The Banks grass mite was originally described in 1914 by Nathan Banks as *Tetranyclus simplex* from date palms at El Centro, California. Pritchard and Baker (1955) placed this mite in a new combination as *Oligonyclus pratensis* (Banks) and listed the host plants including many species of grasses from many regions of the United States. The biology of this mite and its host range were worked out by Stickney et al. (1950).

Injury.—Banks grass mite rasps the surface of the host tissue and injures date fruit by scarring the skin (Figure 1) causing it to harden, crack and shrivel with a subsequent reduction in the grade of the fruit which results in a loss to the grower. A heavy deposit of fine webbing spun over much of the area fed upon collects dust and makes even a moderate population infestation in tall palm trees easy to observe from the ground.

Description and Life History.—The body of the adult female is ovate and about 0.29 mm long, varying from yellowish white to pale orange and with deeper shaded irregular spots along the side of the body. The male adults are bluntly subtriangular and smaller than the female, about 0.25 mm long but with the same coloration. The egg is pearly white, spherical, and approximately 0.13 mm in diameter. The immature mites resemble adult females except that the larvae have only six legs. After molting, they become 8-legged nymphs. Although the number of mites decreases and activity is reduced during the winter months, all stages of development are found throughout the year. The peak populations occur on date fruit in July and August, the first infestation appearing in early June when the fruit is just beginning to develop. These mites unsually do not remain on ripe fruit but maintain themselves during winter months on late ripening or off season green fruit as well as on the foliage of the date palm or on grasses, particularly Bermuda grass, *Cynodon dactylon* (L.) Pers., growing in or near the date gardens. They are incapable of flight and do not spin silk strands to float on the wind as some mites do. Their main means of dispersal besides walking is probably by transportation on particles of dust and debris carried by strong winds.

These winds, quite common to the date growing regions of the United States, probably contribute to the rapid reinfestation by this mite that so often follows successful initial control measures (Elmer, 1962).

Control.—Sulphur dust has been used almost exclusively to reduce injurious populations of the Banks grass mite. Motor driven air blast dusters with tube extensions to reach

the higher bunches are usually used to deposit a light coating of fine sulfur over the entire surface of each date fruit (Figure 2). From 25 to 50 pounds of sulfur dust are used per acre of date palms, 45 to 50 trees per acre. Some growers prefer one sulfur dusting by airplane in the spring before the date bunches are tied down followed by an application from the ground later when mites appear. Vincent and Lindgren (1958) pointed out that best mite control was obtained by blowing the sulfur dust directly up into the branches. Poor coverage and subsequent poor control with sulfur dust result when either the equipment cannot blow the dust to high date bunches or wind during application prevents the dust from reaching these heights.

Dusting sulfur also irritates the eyes of those applying it as well as those working in the trees afterwards. These disadvantages suggested that sulfur and other acaricides might be applied as sprays since wettable sulfur sprays are less irritating to the eyes and are easily applied to the highest date bunches with high pressure spray equipment. Wettable sulfur sprays were used commercially in a few date gardens during 1962. The bunches were thoroughly drenched with the spray at the rate of 200 to 300 gallons per acre (50 trees) with a conventional high pressure citrus sprayer and a shade gun operated from the ground (Elmer 1961). Population levels were reduced sufficiently to prevent injury when 6 to 10 pounds of wettable sulfur per 100 gallons of water were used. Spreaders and stickers added to dusting sulfur and applied as spray seem to hold some promise for more lasting control.

Other acaricides gave excellent control of this mite including dicofol, tetradifon, carbophenothion, and ethion, but none were superior to sulfur. None of these acaricides is recommended for use by the date growers in the United States at this time because they are more expensive than sulfur treatments and because considerable information regarding residue would be necessary to secure federal and state registration for use.

Nitidulid Beetles

Lindgren and Vincent (1953) listed four species (Figure 3) of nitidulid beetle predominant on dates in the Coachella Valley. They are all closely related members of the family Nitidulidae, the corn-sap beetle, *Carpophilus dimidiatus* (Fab.); the dried-fruit beetle, *C. hemipterus* (L.), also called fig or two-spotted beetle; the pineapple beetle, *Urophorus humeralis* (Fab.); and the yellowish nitidulid, *Haptoncus luteolus* (Er.). In 4 out of 5 years (1947-1951 inclusive) more than 90 per cent of the beetles in dates picked from the bunches were *C. dimidiatus*, and the fifth year 75 per cent consisted of this species. Stick-

Fig. 1. Mature Deglet Noor dates that were severely scarred by Banks grass mite before they were fully grown. Application of sulphur dust killed the mites and left the portion of the dates at the stem end unscarred.

Fig. 2. Motor driven air blast duster in operation. Note the tube extensions which enable the operator to direct the dust into the date bunches.

ney (1924) and Barnes and Lindgren (1947) had found, prior to 1947, that *C. hemipterus* had been the dominant species on dates, but for some unknown reason *C. dimidiatus* has replaced *C. hemipterus* as the more abundant species. The other two species, *U. humeralis* and *H. luteolus*, averaged less than 2 per cent of the total beetles found during the years 1947-1951 from dates picked from the bunches.

These four species are quite generally found in date gardens or nearby where decaying vegetable matter occurs, such as grapefruit groves, vineyards, and in truck-crop fields.

Injury.—Injury to dates occurs when the larvae enter the date fruit and feed on the inside. They also carry in fungus spoilage spores, which also contribute to making dates unmarketable.

Description and Life History.—*C. dimidiatus* is oblong, feebly shining in color varying from black with a reddish tinge to brownish-yellow, with the elytra always paler, 2.0-3.5 mm long. This species occurs in all tropical and temperate regions and in all states of the continental United States.

C. hemipterus is oblong, black with buff spots on the elytra, 2 to 4 mm long (Figure 4). It is particularly abundant in tropical and subtropical regions of the world and has been reported from most states in the United States.

U. humeralis is rather broadly oblong, oval and brown to black, usually with a small pale spot within the humerous of each elytra. The upper surface is strongly shining and polished; it is 3.3 mm to 4 mm long, 1.6 to 1.9 mm wide. The largest of the four species described here, it is generally distributed throughout the southern United States and the rest of the world.

H. luteolus is oval, slightly oblong, moderately shining, truncate, uniformly brownish-yellow, 2.0 to 2.5 mm long. The smallest of the four, this species probably is distributed throughout most of the United States.

These beetles develop best at temperatures averaging around 90 F., the average temperature of the Coachella Valley during June, July, August and September. High humidity at this time appears to be very important for the development of large populations of these beetles. Their first new source of dates as food is provided during the June drop. The newly dropped dates are selected by the first beetles, and populations that later will infest dates in the bunches are produced on the ground. A single female over a period of several months may produce 500 to 1,000 eggs.

The beetle larvae pupate in the soil and in this form may over-winter although adults can be found in almost any month feeding on dates on the ground or on other decaying vegetation and fruit in the area.

Fig. 3. Adults of four species of nitidulid beetles found infesting dates. Left to right: *Urophorus humeralis* (F.), *Carpophilus hemipterus* (L.), *Carpophilus dimidiatus* (F.) and *Haptoncus luteolus (Er.).*

Officially recognized common name by the Committee on Common Names of Insects of the Entomological Society of America. The other common names are generally accepted in United States literature by thos concerned.

Control. — Lindgren and Vincent (1953) screened various insecticides in the laboratory to determine the initial and residual toxicity to nitidulid beetles. Materials most affecting these date insects were lindane, chlordane, aldrin, dieldrin, heptachlor, parathion and malathion. Parathion, malathion, and dieldrin, applied to date bunches at the rate of from ¾ to 5 per cent toxic compound and from 1 to 6 weeks before picking, appeared to be the most effective materials of this group. However, since malathion is considerably less toxic to warm-blooded animals than parathion, and some of the other materials imparted an off-flavor to the dates, extensive experiments with malathion were conducted further. A 5 per cent malathion dust in 1952 reduced the live beetles in the bunch from over 9,000 to 60. Up to two weeks following application no live beetles were found in treated bunches, which tended to remain relatively free from live beetles up to 8 weeks. Infested fruit was reduced over 60 per cent. This included the cull dates which are normally discarded. Since 1953, further substantial field experiments with these and other insecticides have been conducted (Elmer

Fig. 4. Date fruit opened to expose injury caused by *Carpophilus hemipterus* adult and four larvae.

1961), but beetle populations were unusually low in most date gardens in the Coachella Valley and no significant results with newer materials have been obtained. Lingdren and Vincent (1953) described fumigation techniques in the packing house for the control of nitidulid beetles.

Raisin moth

The raisin moth, *Ephestia figulilella* Greg. family Phycitidae, first became an important pest of raisins in California in 1928 (Stickney et al. 1950). The biology and control of this moth were discussed in detail by Donohoe et al. (1949). It is presently one of two species of Lepidoptera of economic importance to date growers.

Injury.—The larvae of the raisin moth feed in the dates and develop into adults even after picking if the fruit is not fumigated. This moth feeds on dates late in the season when the first dates are picked. This species along with the Indian-meal moth accounts for a large percentage of the so-called hidden culls which reduce fruit grade.

Description and Life History.—The adult raisin moth is small, about 1 cm long, and gray with a few obscure darker bands an dspots on the forewings. The larvae closely resemble those of the Indian-meal moth, except the white body is streaked with six rows of lavender dots. Full grown larvae are about 16 mm long. The pupae are brown and enclosed in a silken cocoon, spun in cracks of the palm tree, in the topsoil, in storage buildings under boards and boxes, or in convenient cracks. The moths are most active in the early evening and remain in shaded, protected areas during the daytime. They live about 2 weeks in warm weather, but the females lay an average of 351 eggs. A maximum of 692 has been recorded. These eggs are laid on the surface of the dates and hatch in about 4 days. The larvae feed for about a month, then pupate. The winter is spent in the topsoil by well-grown larvae.

Control.—The control of the raisin moth in date bunches in California has been combined with control of the nitidulid beetle and the Indian-meal moth, which infest dates at about the same time. The 5 per cent malathion dust treatment used to control nitidulids has kept the percentage of date fruit infested by these two moth species at a reasonably low level. In storage, methyl bromide gas is used to kill moths as well as beetles or other insects that may have been brought in from the date gardens (see Packing House Procedures).

Indian-Meal Moth

The Indian-meal moth, *Plodia interpunctella* (Hübner), is worldwide in its distribution and has been a pest on dates since they were first planted in the United States. The larvae feed on all kinds of stored products and are of importance as a field insect on only a very few crops besides dates.

Injury.—The adult moths of this species do no damage to dates as they feed only on liquids; however, the larvae do feed on ripe dates in the bunches and in the packing house as well as those on the ground. They enter any break in the surface, chew through intact skin, or more commonly enter the fruit at the calyx end. They seem to prefer the drier, more mature dates in the bunches and even chew on hard date seeds. The larvae spin threads of silk as they feed on the inside of the date and produce webbed-up masses of excreta along with a web covering the entrance hole.

Description and Life History.—The adult Indian-meal moth is about 1 cm long. The outer half of the forewing is reddish brown in color with dark markings and the inner part gray with a copper-colored band separating the two areas. The larvae are dull white and reach a length of approximately 13 mm. When the larvae mature, they usually leave the date to pupate between or under the

Fig. 5. Date bunch showing shriveled and dried fruit caused by Apache cicada avipasitian in the strand. Nate the wedge-shaped avipasitian marked strands in camparisan ta smaath strands.

dates or in cracks in the tree or picking boxes. The pupae are light to dark brown and about 9 mm long.

The adults live from 2 days in summer to 10 days in winter. The females deposit an average of 170 eggs on the skin of the dates. These eggs hatch in 2 to 4 days in early fall, up to 22 days in winter. They may pass up to 4 months of the winter in the larval stage, with a pupal period to 25 days. The entire life cycle may be only 36 days in the summer, to 5 months in the winter.

Control.—The Indian-meal moth was primarily a packing house control problem requiring fumigation of all newly harvested dates. During the past few years more effort has been made to reduce populations in the bunches.

A 5 per cent malathion dust applied first about 3 weeks prior to the first fruit pick is now recommended for control of this moth.

Apache Cicada

The adult Apache cicada, *Diceroprocta apache* Davis, may be found in large numbers during the summer in the desert regions of southwestern United States. They are occasionally of economic importance on certain crops, particularly asparagus, but usually are of only minor importance on dates (Stickney et al. 1950).

During 1961 in one area of southern California a considerable loss in date crop tonnage was directly attributed to the oviposition habits of the Apache cicada female (Elmer 1963). This loss continued for two more years in this area and although adjacent asparagus is evidently a preferred host for the cicada larvae, the problem is of economic importance to those date growers affected.

Injury.—The vitality of the date palm may be lowered by immature stages of this cicada feeding on the roots, but the primary loss is caused by the females laying their eggs in the date strands. Under certain conditions this habit produces sufficient obstruction in the flow of sap in the strand to cause the dates to shrivel, dry up and fall to the ground

(Figure 5). The injury is easily recognizable as a typical wedge-shaped cicada oviposition puncture. Each separate puncture is made vertically up the strand between the first date and the base of the strand.

Description and Life History—The body of the adult of both sexes is stout, broad across the anterior end, and from 3.5 cm to 4.1 cm long. The general color is brown, light to dark on the dorsal side and lighter on the remainder of the body with a prominent light brown band across the back at the base of the wings, which are transparent and have brown veins. The nymphs are brown and thick-set and have strongly developed front legs fitted for burrowing in the ground. This cicada is believed to require 2 years for its development in the ground, where it feeds on the roots of many different plants.

Control.—No insecticidal control is feasible at this time on dates because of the flight habits of the female. Paper covers (Figure 6), which are normally placed over date bunches to protect them from rain, birds, and other insects after ripening begins, were used earlier than normal during 1962 for protection against the Apache cicada (Elmer 1963). Complete protection from any oviposition was obtained in all cases where these covers were used early enough. Uncovered check bunches had from 25 to 80 per cent loss of dates. It is possible, however, that females may oviposit so early that paper covers would have to be used so early that more damage would occur than they would prevent. Checking and "sunburning" due to intense heat under the paper covers occurs to dates covered while still green.

MINOR PESTS

Bees, Hornets, and Wasps

Many different species of bees, hornets, and wasps feed on fresh fruits and often members of this group causes some damage to dates, particularly varieties of soft dates. Growers have occasionally used various types of cloth covers to protect their crop from these pests as well

Fig. 6. Date bunch cavered with paper caver in faregraund is representative af the type used to cantral the Apache cicada. The other bunch is covered with cheese clath which, wauld give camplete pratectian fram almast all insect pests but is mare castly ta install. Man in faregraund is applying dust with a hand applicatar af a type that can best be used on law grawing date trees.

as against rain and birds (Bliss et al. 1950).

Datebug

The datebug, *Asarcopus palmarum* Horv., first noticed in date plantings in 1922, have at times caused considerable weakening of young palm trees but generally do not obviously affect mature or healthy young trees. They are members of the family Fulgoridae and feed largely on the white tissue of the current season's fruit stalk. When they become numerous enough on small, weak palms, they may cause the terminal leaves to droop, but control of this pest is generally not necessary except in a few isolated cases.

Date Stone Beetle

The date stone beetle, *Coccotrypes dortyliperda* (F.), is a close relative of the bark beetles but feeds primarily on fruit seeds. Because of its fondness for vegetable ivory—the seeds of several species of palm from which buttons are made—it has been called the button beetle. In the date growing regions of the United States it feeds only on waste dates and causes no loss to growers.

European Grain Moth

Nemapogon granella (L.) was reported to have infested stored dates in Los Angeles, California, in 1932.

Fig Beetle

The fig beetle, *Cotinis texana* Casey, is found in all the date growing regions of the United States but seems to prefer figs, peaches and grapes to dates. A few instances of serious damage to dates have been recorded during years of above normal humidity. Fermenting fruit is preferred by this beetle, but like the nitidulid beetles it will puncture and enter uninjured fruit. A. A. Nichol (1935) gave a detailed account of the fig beetle.

Giant Palm Borer

Dinapate wrightii Horn is the largest species in the family Bostrichidae in the world, reaching an adult length of 5.71 cm. This borer attacks California fan palms in the foothills of the Coachella Valley and occasionally has been found in an isolated date palm in that area but fortunately not in dates on the valley floor.

Hairy Fungus Beetle

The hairy fungus beetle, *Typhaea stercorea* (L.), is a brown beetle of the family Mycetophagidae, or fungus eaters, and is common on moldy dates on the ground. They do no damage to dates in the bunches.

Merchant grain beetle

The Merchant grain beetle *Oryzaephilus mercator* (Fauv.), the saw-toothed grain beetle, and the rusty grain beetle are typical packing house insect pests. They are seldom found in newly picked dates arriving at the packing house but somtimes infest dates that have been allowed to dry out in storage. Fumigation, sanitation in the packing house, and high humidity keep these three pests under control.

Mites (in stored dates only)

Many species of mites are a very serious past if once established in stored dates. Fortunately these infestations are rare, but when they do occur the best means of combatting them is to destroy the infested dates.

Navel Orangeworm

Larvae of the navel orangeworm *Paramyelois transitella* (Walker), occasionally infest dates in much the same manner as the Indian-meal moth and the raisin moth.

Palm Rhinoceros Beetle

Strategus julianus Burm. adults seem to prefer small, immature palms including date palms. They burrow into the palm trunk just below the soil level often near the terminal bud and may fatally injure the young tree. They are particularly damaging in nurseries, but once the tree reaches a certain age, it seems to be immune to the feeding of this beetle.

Red date scale

The red date scale, *Phoenicococcus marlatti* Cockerell, is the only scale insect attacking date palms in the United States, since the parlatoria date scale was eradicated. It is found on the protected white tissue of leaf bases, on fiber bands, and on fruit stalks, but fortunately even high populations do not seem to affect the vigor of the tree or the amount of fruit yield. Stickney et al. (1950) gave a very good description of this scale insect.

Rusty grain beetle

Cryptolestes ferrugineus (Stephens) See the merchant grain beetle.

Saw-toothed grain beetle

Oryzaephilus surinamensis (L.), See the merchant grain beetle.

Vinegar flies

Flies of the genus *Drosophila* are abundant in many kinds of fermenting materials, including sour dates. They seldom cause any injury to fresh fruit but are a pest in packing houses if they become abundant enough in souring dates to deposit excrement on marketable dates. Sanitation and removal of all fermenting dates will eliminate this problem.

Western Leaf-Footed Bug

Leptoglossus zonatus (Dallas) is a sucking bug that seems to prefer pomegranates but also feeds on many other fruits and vegetables. The bugs have been known to infest dates adjacent to pomegranates.

PACKING HOUSE PEST CONTROL PROCEDURES

Dates arriving at the packing house in field boxes are placed in fumigation sheds open at both ends to expedite the removal of both the gas and the dates. As in earlier recommendations, one pound of methyl bromide per 1,000 cubic feet is used, but for 4 hours instead of 24 hours. This shortened exposure time apparently is sufficient to meet packing house marketing requirements. These fumigated dates are then inspected by government as well as packing house employees to determine the percentage of hidden culls in each group of dates purchased from a particular grower. Methods for determining hidden culls vary among packing houses, but generally a sufficiently large sample from each lot is taken and a certain number of dates are cut open and examined for evidence of insect bodies, excrement and debris. If the percentage of hidden culls is higher than government standards allow, such dates are handled separately and graded as substandard dates for market or by-product use.

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STATUS OF DATE PRODUCTION IN THE YUMA AREA

By C. W. VAN HORN

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Interest in the growing of dates either in Yuma Valley or on Yuma Mesa is now almost non-existent. Even though Yuma Valley some years ago was the source of many date offshoots that were planted in the Indio area, now there are only a few small gardens. None of these should be considered well developed commercially.

However, on the California side of the Colorado River across from Yuma, several small gardens have been planted in the past five years or so. Each of these plantings is of the Medjool variety. Interest was aroused by the outstanding job done with this variety by Stanley Dillman, who recently sold the property but still lives there.

It is a pleasure for me to attend another Date Institute. It is a particular pleasure for me to be chairman of the afternoon session following Dr. Hilgeman for the morning session. Soon after Dr. Hilgeman started his research work on dates at Tempe, Arizona, I worked for him as a day laborer.

DISEASES OF THE DATE PALM

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INTRODUCTION

Date palms demand large quantities of water for growth and fruiting in the hot deserts where they thrive, yet atmospheric moisture is their commonest enemy. Most of the important pathogens of palms are fungi and, except for the destructive soil-borne species of *Fusarium* that causes bayoud, are dependent upon high humidity and rain for their development. Thus, except for bayoud the fungal diseases of date palms are of only sporadic importance in the more favored date-growing districts, but are increasingly common and damaging in date culture as conditions become suboptimal to marginal because of poorly distributed or excessive rainfall and high humidity. Neither bacterial nor viral diseases have been definitely associated with date palms, and well-defined mineral deficiency disorders are unknown.

More than 30 years have elapsed since Chabrolin (18) and Fawcett and Klotz (31) published general reviews on date diseases. Viennot-Bourgin (75) reviewed the fungal diseases of dates. Recently, Nixon (59, 62) summarized the information on diseases of dates in the United States and Calcat (12) discussed palm diseases in the Sahara and North Africa. In addition, valuable discussions of environmental factors influencing date culture were contributed by Caty (14) and Pereau-Leroy (66).

The following information has been adapted with little change from a comprehensive review of pests and diseases of the date palm prepared by H. S. Elmer, University of California, and the authors for the Food and Agricultural Organization of the United Nations.

BAYOUD

Introduction — Bayoud, or "fusariose", the most important disease of date palms, is confined to Morocco and southwestern Algeria, but is a menace to date palms everywhere. The causal organism is *Fusarium oxysporum* Schlect. var. *albedinis* (Killian & Maire) Malencon. Cipolla (19) reported studies of a fusariose on date palms in Argentina that might be related to bayoud. Pereau-Leroy (64, 65, 66) summarized the history of bayoud and previous investigations, including the extensive and valuable contributions of Malencon. Teisseire (70) emphasized means for controlling bayoud. In 1965 Toutain (71) reviewed the bayoud problem in Morocco and Algeria, and recent investigations by Louvet, Toutain, and others were summarized in 1966 (34).

Distribution — Bayoud was observed first in Morocco north of Zagora in the Draa Valley sometime before 1890. Since then it has spread continuously and by 1956 the only date-growing area in Morocco still free of bayoud was at Marrakech, north of the Grand Atlas mountains. Bayoud spread more rapidly towards the east than the west (71), and by 1898 was recognized at Figuig on the edge of the Algerian Sahara. Thereafter, bayoud appeared in several locations in Algeria south and west of El Golea. Bayoud appeared in date plantings at Metlili, north of El Golea sometime between, 1949 (71) and 1958 (12).

Economic Importance — By 1950 bayoud had killed 10,000,000 palms in Morocco (66), including the greater part of the vigorous and productive palms of the best commercial varieties, such as 'Medjool' and "Bou Feggous'. The remaining 5,000,000 palms were predominantly seedlings and varieties of only local interest. Areas that formerly had 300 to 400 palms per hectare, and where intercrops were virtually unknown, such as at Bou Denib and at Haut R'teb, were reduced to 5 to 10 palms per hectare. The losses are compounded by the fact that in many oases with an irregular surface water supply the loss of date palms removes the staple food crop and medium of exchange for which there are no adequate substitutes. Even in oases receiving a regular supply of surface water no other food crop gives yields comparable to those of date palms. The ravages of bayoud have forced emigrations of the population from some severely-affected areas.

Since the fine commercial 'Deglet Noor' date is susceptible (12, 71), bayoud is a particular threat to the principal date-growing areas of Algeria and Tunisia because of intra-Saharan traffic among desert peoples.

Symptoms — Symptoms of bayoud appear first on 1 or more of the recently matured leaves in the middle ranks of the top. Typically, some spines or pinnae towards the base of 1 side of the leaf become white and then adjacent spines or pinnae whiten as the disease progresses upwards along 1 side of the rachis to the apex. After 1 side is involved, the whitening and dying of pinnae progress down the opposite side of the leaf until it is killed. This may require a few days to several weeks. As the pinnae die, a brown stain appears on the dorsal side of the rachis and the diseased area becomes depressed. The stain and depression may extend the length and width of the rachis, except on the part hidden under the fiber which remains alive and turgid indefinitely. A transverse cut through the affected parts of the rachis reveals brownish-red necrotic areas.

Concurrently, adjacent or opposite leaves are affected in like manner until finally 1 or 2 whorls of leaves are killed. The old leaves wither naturally as on unaffected palms, but no new leaves form and the terminal bud dies, leading to death of the tree. The average time from the appearance of symptoms to death is 6 months to 2 years; however, trees may die in 1 month or linger for 10 years or more.

Sometimes the symptoms develop differently. A brownish lesion may appear on the back of the rachis and extend upwards until the rachis is so narrow that all tissues are involved and the whole tip of the leaf whitens and dies. The other pinnae then die downwards to the base. Other minor variations may occur in the early symptoms, and diseased pinnae may be tinged brownish or reddish depending upon the variety affected. Experienced observers may detect a general slight yellowing in some recently matured leaves 1 or 2 months before the appearance of typical symptoms.

When the trunk of an affected palm is split, vertical reddish bands of diseased tissue 1 to 2 cm long as well as individual discolored vascular fibers may be seen. Some diseased roots are also present on affected trees; E. Laville has indicated in correspondence that 4 or 5 diseased roots among the 800 to 1,000 adventitious roots on a large palm are sufficient to insure infection. Malencon (49) and Pereau-Leroy (66) suggested that death might result from some toxic effect of the fungus rather than from simple congestion of the vascular tissues. They thought this might explain why the offshoots of a diseased tree may persist and develop for up to 10 years after the death of the parent.

Fungus — The fungus, *F. oxysporum* var. *albedinis*, may be found in infected, discolored tissues, particularly in the base of the rachis, as hyaline mycelium between and within the cells. Microconidia usually occur in groups in vessels and other cells, but they may occur singly.

In culture (66) this fungus produces a rose to violet stain in the medium. Great numbers of spherical to elongated and slightly curved hyaline microconidia are formed, most of which are unicellular; their measurements are 3-15 x 3-5μ. The falcate macroconidia are usually 3-septate and measure 20-35 x 3-5μ. The intercalary and terminal chlamydospores are spherical and occur singly or in groups of 2 or 3. Sclerotia are dark blue to black, 1-2 mm in diameter, and occur rarely.

The optimum temperature range for growth of the *Fusarium* is 21 to 27.5 C, but it grows reasonably well in temperatures as low as 18 C or as high as 32 C. Thus, irrigated soils in areas such as Ksar el Souk, Morocco, maintain favorable temperatures for development of the fungus from May through October. The fungus may sporulate abundantly on date trash on moist ground.

Infection — The causal fungus of bayoud is soil-borne and can be spread locally by water, wind, diseased offshoots which move soil from diseased areas, or in infected date tissues, especially infected wood or pieces of rachis. The henna bush, often grown among date palms, is a symptomless carrier of the fungus (34). Infection of palms takes place principally through roots. Pereau-Leroy (66) and Malencon (48, 49) were unable to find a satisfactory technique for consistently infecting roots and producing symptoms of bayoud in palms, but Laville (43), working with seedlings, showed that *Fusarium* does attack roots and may enter the plant through the root system and cause death. Malencon (47) demonstrated floral infections by *Fusarium*, but this type of infection is rare and establishment of bayoud in the palm as a result of floral infections was not demonstrated.

The spread of bayoud to isolated oases and larger date-growing areas was ascribed by Malencon (49) to movement of the fungus in articles made of palm tissues, such as pack saddles, baskets, and ropes, and Pereau-Leroy (66) found that the pathogen persisted at least several weeks in infected rachis tissues. When such articles are discarded in a moist place favorable for the fungus, it can resume growth, become established in the soil and infect palms. Bayoud assumes epidemic proportions only when a combination of the pathogen, a susceptible variety, and abundant surface irrigation water exists. Laville and Lossois (44) made a statistical study of the spread of bayoud at In Salah, Algeria.

Diseased trees of susceptible varieties probably never recover but the advance of infections may be retarded by drastically reduced irrigation. This, however, renders the trees unfruitful, and the crop is lost either by drouth or disease.

Control — The use of resistant varieties is the most practical means of controlling bayoud. Among 6 resistant varieties listed by Pereau-Leroy (66) only 'Takerboucht' and 'Bou Ijjou' were of acceptable quality although certainly not equal to

'Deglet Noor' or 'Medjool'. Breeding might combine resistance to bayoud with the desirable fruit and growth characters of some of the superior commercial varieties. A long-term program for breeding and selection of superior, resistant date varieties for local use and export was begun in Morocco by Pereau-Leroy (65, 66) and, after a period of inactivity, has been revived and augmented (34).

Meanwhile, moderate yields of dates and some mitigation of bayoud may be obtained by careful irrigation practices and the planting of resistant or semi-resistant varieties. Irrigation on infested soil has a profound direct influence on the development of bayoud, and intercrops, especially henna, may have an indirect influence by maintaining high levels of inoculum, according to E. Laville (correspondence). Palms of susceptible varieties growing in infested soil cannot endure surface irrigations at any season, but if planted in basins may be grown successfully over a permanent water table at a depth of 4 to 5 feet.

Semi-resistant varieties may be grown successfully if surface irrigation is used primarily for inter-crops and only between October and May. Resistant varieties tolerate surface irrigation and inter-crops at all seasons.

The need for strict quarantine measures to prevent or delay the spread of bayoud, and incidently other pests and diseases of the date palm, has been recognized by Delassus and Pasquier (26), Maire (45), Crossa-Raynaud (21), and others. The first F. A. O. International Technical Meeting on Date Production and Processing (33) recommended enforcement of quarantine measures against bayoud. Algeria (70) enacted quarantines in 1942 and 1949 and strong quarantine measures have been enforced in the Sahara and North Africa (12). Mauritania adopted quarantine measures against bayoud in 1953 (57). The United States (74) and some other date-growing countries have quarantine regulations covering movement of date palms and date-palm products.

KHAMEDJ

Introduction — Khamedj, or inflorescence rot, is generally present in date-growing areas in North Africa from Morocco to Libya (17, 51). It has also been reported from Iraq (2, 36), Italy (18, 30), Mauritania (56), Palestine (67), and Tunisia (21). Although inflorescence rots had been known for a long time, Cavara (15, 16) published the first technical reports on this disease, followed by the work of Chabrolin (17, 18). Khamedj is a general term for inflorescence rots (12) but refers primarily to that caused by the fungus *Mauginiella scaettae* Cav. Calcat (12) and R[ayner?] (67) published recent accounts of khamedj. Inflorescence rots of minor importance are caused by species of *Ceratocystis* (see "Black Scorch") and of *Fusarium* (8).

Economic Importance — Khamedj is a common but ordinarily minor disease problem; however, occasionally the losses may be substantial. *M. scaettae* is destructive principally in areas with excessive or prolonged winter and spring rains, on neglected palms in marginal areas, or on waterlogged soil, in salty basins, or in lowlands. Male palms, which frequently grow in marginal areas of oases and are community property, may be especially heavily infected because they receive little attention except as pollen sources; the old inflorescences are not removed regularly. The fungus can survive in all parts of infected inflorescences and, if these are not destroyed, the fungus may attack and ruin part or all of the new inflorescences on such palms in years favorable to the disease. Fortunately, the affected palms, both male and female, are usually scattered and the disease does not seem to spread rapidly.

Chabrolin (17) estimated that the losses might average 30 to 40 kg. of fruit on severely-affected palms. Trabut (72) estimated that 5% of the palms were affected by khamedj in the southern Constantine area of Algeria, and Chabrolin (18) indicated that up to 10% of the palms might be affected in plantings on heavy, wet soils. The disease is so important in some Saharan oases (17) that the inhabitants developed empirical means of control, including sanitation and crude chemical treatments, prior to the establishment of modern control measures. Inflorescence rot is the only date disease of economic importance (2) among the 30,000,000 palms in the Tigris and Euphrates valleys of Iraq, principally between Baghdad and the Persian Gulf. In Iraq, important outbreaks are sporadic and occur only after prolonged cold, humid weather in the winter. Fawcett (30) considered inflorescence rot the most important disease of date palms in Tunisia.

Symptoms — The disease appears when the spathes begin to emerge in late winter or early spring. At first affected spathes are barely distinguishable from normal ones. Brownish or rusty areas develop on the unopened spathe after the fungus has already invaded the floral tissue. Lesions may be confluent and are most common near the top of the spathe, which at the time of infection is soft and still hidden in the leaf bases. The internal face of the spathe under the lesions is yellow and translucent and may show brown dots corresponding to points of contact with diseased flowers. The fungus attacks flowers and strands and may move on to the stalk of the inflorescence. Spathes severely damaged when young may remain closed. However, the spathe usually splits and reveals partial to nearly complete involvement of the flowers and strands. Characteristically, certain infected palms show annual damage, whereas others in the same planting have only an occasional inflorescence attacked even under conditions favorable for disease development.

Fungus — In culture (17) *M. scaettae* develops a flat, white to cream-colored mycelial mat that is soon covered with chains of hyaline conidia which give it a powdery appearance. The conidial chains fragment into units of 1 to several cells about 10-50μ long and 5-10μ wide. One and 2-celled units predominate. The same type of sporulation occurs on infected palm tissues. Germination is much better in tissue extracts or decoctions than in water.

On infected tissues the fungus forms a distinctive white mycelial weft that disappears, but leaves a whitish bloom of spores on the surface. Spores are considered to be short-lived and not of much importance in the persistence of the fungus which apparently survives in old tissues as mycelium. The fungus, which is capable of direct penetration of the spathes, is an aggressive parasite. The role of contaminated pollen in the spread of the disease seems to have been ignored and, as R[ayner?] (67) pointed out, no detailed studies of dissemination, infection, and host-parasite relations have been reported. R[ayner?] (67) considered that *M. scaettae* would not spread readily into uncontaminated areas because the spores are short-lived and transportation of infected tissues would be negligible. Nevertheless, in France, Anselme and Baltzakis (3) found this pathogen occurring as a rot of packed date fruits where a piece of infected strand was included. Fancy packs of 'Deglet Noor' dates from North Africa often contain a piece of strand for decoration.

Control — Good sanitation is the first step in the control of khamedj. All diseased parts of the inflorescence should be collected and burned immediately after harvest, and in all trees the old flower stalks and spathes should be cut out as completely as possible and removed from the planting. Fungicides should be applied immediately after harvest on the old flowering area of diseased palms, and in early spring on the new flowering area just before the spathes emerge. Chabrolin (17) reported good control by spraying with bordeaux mixture or a strong lime-sulphur solution, or by dusting with a copper sulphate-lime mixture, essentially powdered bordeaux mixture. The dust was cheaper and more easily applied than spray in small plantings. According to Teisseire (70), the 'Ghars' variety is more susceptible than 'Deglet Noor'. 'Tafezouine', 'Hamraia', and 'Takermest' are resistant.

FRUIT ROTS

Distribution and economic importance—Pre-harvest fruit rots may be caused by a large number of fungi (7, 31) and occur wherever dates are grown. The economic importance of fruit rots is highly vari-

able, since the incidence of rots is governed by the occurrence of rain and high humidity during the khalal and later stages of ripening. Darley and Wilbur (25) reviewed the fruit spoilage situation in California. Although losses of 25% or more have occurred sporadically in individual gardens or districts, they estimated the annual loss from fungus spoilage at about 5% when paper covers, fungicidal dusts, and spreader rings were used. When the cost of controlling fruit rots is added to the loss of fruit, fruit rots become the most important disease of dates in California.

Estimates of loss from fruit rots are seldom reported from the date-growing areas of the Old World, although such rots occur. Kearney (38) noted that rains at harvest time in Tunisia sometimes caused serious losses of fruit. To circumvent rain damage, dates are often harvested either individually or in bunches while in late khalal to early rutab stages and the fruits are ripened on mats, on hurdles, and in other ways (12, 27, 28, 52). In Algeria (12) late-maturing varieties like 'Deglet Noor' may be damaged by rain and fruit rots in unfavorable years with losses reaching 25 to 30% In Israel (20) fruit rots occur in late varieties like 'Deglet Noor' and 'Barhee'.

Pathogens and disease development — Species of *Alternaria, Helminthosporium,* and *Macrosporium* may infect fruits directly, beginning in the khalal stage. *Citromyces ramosus* Bain. & Sart. and *Aspergillus niger* v. Tiegh. may cause a calyx-end rot in the late khalal or early rutab stage. Rieuf (68) discussed *A. niger* and *A. phoenicis* (Cda.) Thom in relation to date fruit rots. These and numerous other species of saprophytic fungi, among which yeasts are important, also invade ripening fruits through wounds, especially during periods of rain and high humidity when fruits may split and crack and provide easy entry for fungi.

'Deglet Noor' is especially liable to such injury. Nixon's (62) discussion of the factors involved in fruit rots is of general application in date culture.

Control—Losses from fruit rots may be reduced by several means (25, 62). In the United States, the following procedures, used alone or in combination and mostly on 'Deglet Noor' palms, have been effective in reducing fruit rots. Prior to the khalal stage, wire rings may be inserted in the bunches to promote good ventilation and drying of wet fruit. Even in the absence of rain, dew may form on low-hanging fruits of young palms and rather humid conditions may prevail because of weeds or cover crops and soil moisture. During the early khalal stage, a dust compounded of 5% ferbam and 95% dusting sulfur, available under several trade names (62), may be applied to the bunches to reduce fungal spoilage. Incidentally, the dust also discourages some insects (6). At the same stage of growth the bunches of 'Deglet Noor' are covered with paper wraps or bags to exclude rain. Fruit rots may be aggravated by cultural conditions that increase humidity, such as weeds, intercrops, and standing water, and these conditions should be considered in planting and maintaining date orchards.

GRAPHIOLA LEAF SPOT

Distribution and Economic Importance — Graphiola leaf spot is caused by *Graphiola phoenicis* (Moug.) Poit. It is the most widespread disease of date palms and probably occurs wherever the palm is cultivated under humid conditions (31). In most date-growing areas where *Graphiola* is common, the palms are frequently seedlings or of inferior varieties (61) and yields may be reduced by premature death of the leaves. Dates are, nevertheless, an important crop even under such conditions.

Graphiola leaf spot is common on palms in the Punjab (52) where rainfall ranges from 15 to 60 cm during March to August, inclusive. Fawcett (30) found leaf spot the most common disease of dates in Egypt, especially in the Delta and at Fayoum. He believed that the commonly severe infections near the coast "must interfere considerably with the growth and production of the palms". In Egypt, old and diseased leaves are removed as a sanitary measure; Fawcett (30) implied that excessive pruning could reduce date yields. Leaf spot often occurs in the humid coastal areas of North Africa and the Middle East (51, 60, 61, 63), but the disease is of little importance in the principal interior date-growing areas of North Africa (18). *Graphiola* causes serious damage to palms in several of the southernmost, humid date-growing areas of Senegal, Mauritania, Mali, and Niger (50).

Pathogen and Disease Development—*G. phoenicis* was described by Fischer (32), and Killian (41) established its taxonomic position as one of the smut fungi. The fungus develops subepidermally in small spots on both sides of the pinnae and on the rachis. Finally the fruiting structures emerge as little black, covered sori, or pustules, and are often numerous.

The sori are 1-3 mm in diameter and consist of 2 layers; the outer peridium is hard, dark, and persistent, but the inner hyaline peridium is thin and degenerates after the spores mature. Spores are produced in fertile areas of the sori and are interspersed with groups of sterile filaments. At maturity the sori open to liberate masses of yellow spores. Individual spores are spherical to ellipsoidal, 3-6μ in diameter, and have a thick, smooth, hyaline wall. After the spores are disseminated only the rough black craters of the sori remain. Heavily infected leaves die prematurely.

Control — Leaf pruning (30, 52) is the usual practice for reducing damage from *Graphiola* leaf spot. Spraying with bordeaux mixture has been recommended by Milne (52) and later authors. Nixon (61) studied the relative susceptibility of date varities in Texas to infection by *G. phoenicis*. He concluded that a few varieties, especially 'Kustawy', were tolerant to *Graphiola*. Tolerant varieties might be useful either directly or in breeding improved varieties.

BLACK SCORCH

Black scorch, which includes in part medjnoon, or "fool disease" (35), is a minor disease of sporadic occurrence. It is caused by *Ceratocystis paradoxa* (Dade) C. Moreau. The fungus is ordinarily present on date palms only in the imperfect *Thielaviopsis* form. Black scorch has been reported from Tunisia and Algeria (30), Egypt (9, 30), Saudi Arabia (60) and the United States (42). In Mauritania Brun and Laville (10) found this fungus associated with the bending head disease described by Munier (57). No estimates of loss are available.

The investigations of Klotz and Fawcett (42) and Streets (69) provide the principle information on black scorch. All parts of the palm are susceptible to infection by *C. paradoxa,* but its effects are usually expressed in 4 rather distinct ways: as black scorch on the leaves, as an inflorescence blight, as a heart or trunk rot, and as a bud rot on palms of all ages. The infections are all characterized by slight to extensive necrosis of the tissues. Bud rot and heart rot, though uncommon, are the most damaging manifestations of *C. paradoxa* and may kill the plant. Some palms recover, probably by development of a lateral bud, and the palms have a characteristic bend in the region of infection. This is the medjnoon, or fool disease, symptom.

The imperfect form of *C. paradoxa* develops rapidly on host tissues or in culture and produces long chains of endospores which fragment readily. Two types of spores are produced: hyaline, cylindrical microconidia, measuring 5-15 x 3-7μ and dark, egg-shaped macroconidia, measuring 11-7 x 7-15μ. Between the 2 types may be found all gradations in size and shape and intensity of brown coloration.

Infected tissues discolor to a blackish-brown, then shrivel and form conspicuous lesions with a scorched carbonaceous appearance. Dark conidia may develop abundantly on the lesions. In the case of bud rot and of inflorescence rot, where the tissues invaded are relatively soft and moist, secondary organisms may develop rapidly and augment the damage. Black scorch has been observed on 17 date varieties. No infections were

found on 'Tazizoot', and 'Deglet Noor' seemed less affected than othtre commercial varieties. 'Thoory' was the most susceptible variety. *C. paradoxa* may be partially controlled by removing and burning all infected leaves and inflorescences. Dusting of the area where the inflorescences emerge with powdered bordeaux mixture in early spring is a suggested control measure.

DIPLODIA DISEASE

Diplodia disease is a minor disorder caused by *Diplodia phoenicum* (Sacc.) Fawc. & Klotz (31) in the United States, although a second species, *D. natalensis* P. Evans, was reported on date palms in Israel (53). The disease has been reported also from Egypt and Tunisia (30). No estimates of loss from *Diplodia* disease are available. Fawcett (29) investigated this disease in California, where at one time *D. phoenicum* caused considerable damage. The fungus may infect and even kill young offshoots at the base of palms; it may infect the outside leaves and then finally kill the younger leaves and terminal bud, or the central leaf cluster may die before the older leaves die. Yellowish-brown streaks 15 cm to about 1 m in length extend along the leaf base and rachis. The lesions become brownish; internal infection and necrosis may be extensive in leaf tissue. The disease was observed on 17 varieties in Cailfornia.

The most common spores of *D. phoenicum* in cultures or in dead tissues are hyaline. Mingled with them are the typical dark, septate spores of *Diplodia* which measure 22-24 x 10-12μ. The light colored spores are somewhat larger and mostly unicellular. Dark, intercalary chlamydospores are produced abundantly in culture. Pycnidia may develop on dead leaf tissues.

The fungus usually enters palms through natural or artificial wounds. Recommended control measures consist of dipping diseased offshoots, or those suspected of being infected, in ammoniacal copper carbonate solution and annual spraying of offshoots with the same fungicide. Disinfestation of pruning tools is suggested.

OMPHALIA ROOT ROT

Omphalia root rot (5, 39, 40) is a minor disease of date palms in the United States. The causal fungi, *Omphalia tralucida* Bliss and *O. pigmentata Bliss*, are generally distributed in palm plantings in the Coachella Valley of California and have been isolated from the roots of many varieties and seedlings. Although *Omphalia* spp. are pathogenic on palms (5), apparently no constant association exists between the presence of these fungi and visible decline symptoms. The fungi have been isolated from both healthy and declining palms, but not all declining palms—as indicated by loss of vigor. stunting, and unfruitfulness—yielded these fungi (39). Poor cultural practices apparently produce identical decline symptoms, especially in 'Deglet Noor', which at one time was considered especially susceptible to *Omphalia*. KenKnight's (39) data showed plantings of 'Deglet Noor' to have a lower percentage of infected palms than those of any other commercial variety at the time of his survey, 1945-1948.

BELAAT

Belaat refers to a minor disease of the date palm caused by *Phytophthora* sp. in Algeria. It was first described by Maire and Malencon (46), and Maire (45) published a detailed account. Monciero (55) and Calcat (12) have discussed it more recently. No estimates of the losses caused by belaat have been published.

Belaat usually occurs in neglected plantings. On affected palms the entire central cluster of young leaves turns white rather rapidly. Infection occurs near the growing point as a wet heart rot that kills the bud and the bases of the youngest leaves. The infection may be arrested a short distance below the bud or continue downward. Secondary organisms follow the initial infection closely. Some affected palms recover by growth of a lateral bud. Offshoots of diseased palms usually remain healthy.

LE COEUR QUI PENCHE

"Le coeur qui penche", or bending head, is an uncommon but fatal disease reported from Tunisia (35), Egypt (9), and Mauritania (57), where Brun and Laville (10) found *Thielaviopsis paradoxa* and *Botryodiplodia theobromae* (Pat.) associated with it. They suggested that these fungi are essentially secondary parasites, attacking palms weakened by drouth or poor cultural practices.

The symptom which suggested the name 'le coeur qui penche" (57) results from a grouping of the terminal leaves into an erect fascicle with a bent tip. These leaves eventually die and fall over. Meanwhile, older leaves die and hang vertically. These symptoms are commonly associated with a basal heart rot in the palm. In the case of a bud rot or infection of the upper stem, the leaves may die and fall more or less to one side. The symptoms may be intermediate and are not always diagnostic of the type of rot involved. In any case, after the palm dies the trunk bends and may break. Munier (57) recommended that all portions of infected palms be burned on the site to reduce the possibility of spread of the disease.

NEMATODES

Root-knot nematodes were found in the Coachella Valley of California on date palms in 1925 (73) and are now known to be widely distributed there in commercial date plantings. Buhrer *et al.* (11) first reported the occurrence of root-knot nematodes on this host. Authors after 1950 identified the nematodes as *Meloidogyne* sp., except Jensen (37), who reported *M. incognita* (Kofoid and White, 1919) Chitwood 1949, on roots of date palms in western nurseries. Carpenter (13) reported that root-knot nematodes, principally *M. javanica* (Treub 1885) Chitwood, 1949, can severely damage or kill date palm seedlings. Young seedlings of 50 date varieties were susceptible to infection by root-knot nematodes; more than 90% of the seedlings were killed prior to emergence when seeds were sown in heavily infested soil. Secondary damage by fungi to roots of infested field-grown palms seems to be an important factor in the deterioration and death of roots. Minz *et al.* (54) reported on occurrence and control of root-knot nematodes on date palms in Israel.

BLACKNOSE

Blacknose is a physiological disorder of date fruits reported from the United States and Egypt. The melanose described by Munier (57) appears to be the same disorder and is reported to occur in Mauritania and throughout North Africa. Although no official statistics are available, in California the annual loss from blacknose on 'Deglet Noor' dates may approach 5% of the crop. About 80% of the acreage in California is planted to this variety. Exceptional losses of 50% or more in individual plantings have been reported (58). In lower Egypt (9) 'Hayani' is the most susceptible variety and the one most widely grown.

Blacknose results from excessive checking of the epidermis, especially in the form of horizontal cracks at the stylar end of the fruit, and subsequent drying and deterioration of the underlying tissues. Aldrich *et al.* (1) summarized the literature on blacknose and reported on physiological investigations of checking in 'Deglet Noor' dates. Nixon (62) has given a more recent account. Checking is induced by high humidity and rainfall at the late green stage just before the fruit acquires its khalal color. Therefore, conditions tending to increase humidity such as standing water, excessive soil moisture, intercrops, and weeds should be avoided, especially at this stage of fruit development. Over-thinning can also increase the incidence of checking and subsequent development of blacknose. Careful attention to irrigation, cultivation, thinning, and ventilation may mitigate the damage.

BARHEE DISORDER

Barhee disorder is the name given to a bending of the crown of 'Barhee' date palms (22, 23)that occurs in most of the bearing plantings of this variety in California. Affected palms are usually over 10 feet tall and have a bend of 5 to 90° from the perpendicular; 80% of the palms tip to the south. About 50% of the palms in a 10 to 33-year-old planting

have been affected for at least 6 years. The number of fruiting bunches is reduced in direct relation to severity of bending. Affected trees may improve and resume upright growth. Neither the cause nor the control of this disorder is known. Barhee disorder does not appear to be related to "le coeur qui penche" (10, 57) or to "bending head" (27). The 'Barhee' palms in California are all derived from a single importation from Basrah, Iraq, in 1913.

CROSSCUTS

Crosscuts, which appear as clean breaks in the tissues of the lower part of fruit stalks on palms, may vary from a slight notch to extensive or complete breakage of the stalk. Fruits on strands in line with the break wither and fail to mature properly. 'Sayer' is especially susceptible to this disorder, and in the United States up to one-fourth of the crop may be lost. In 1934, about 1000 fruit bunches were lost because of crosscuts in a single planting in California. 'Khadrawy' is also liable to crosscuts. Bliss (4) concluded that crosscuts resulted from an anatomical defect in the fruit stalk involving internal, sterile cavities or fractures that led to mechanical breakage during elongation of the stalk. R. W. Nixon, in conversation, indicated that crosscuts are most commonly found in varieties having crowded leaf bases and that the incidence of crosscuts increases as the palms age. Crosscuts may be avoided by using non-susceptible varieties, or losses reduced by leaving a few extra fruit stalks per palm on susceptible varieties (4). Similar crosscuts or v-cuts occur occasionally in leaves (31).

RAPID DECLINE

Rapid decline, or rhizosis, is a minor but fatal disease of unknown cause on date palms in the United States, where it has been observed in California for more than 30 years. Darley and Wilbur (24) reviewed previous work on this disease and reported new investigations. The onset of symptoms is rapid. Typically, vigorous female palms in full production suddenly drop a large part of the immature fruits in summer, but, if the palm is affected later, the fruits shrivel on the bunch. A reddish-brown discoloration occurs on pinnae of the oldest leaves and almost simultaneously the unexpanded young leaves wilt. Mature leaves die rapidly and progressively towards the top of the palm. Offshoots, if any, usually perish with the parent plant and thus the disease tends to be self-limiting. Male palms also are affected. There is no indication of a disease pattern, since individual affected palms occur at random. No varietal resistance has been noted. Serious losses have occurred in only a few plantings.

DRY BONE

Dry bone is a minor disease of the date palm reported from Egypt and Tunisia (30) and the United States (31). Fawcett and Klotz (31) thought it might be caused by a bacterium. The principal symptoms on the leafstalks, midribs, and pinnae are whitish, irregular blotches and streaks that become sharply delimited and may have reddish-brown margins. The lesions vary from 1 to several cm in greatest diameter, but involve only the epidermis and a thin layer of subjacent tissue.

BLACK SCALD

Black scald is a minor fruit disease of unknown cause reported by Nixon (62) in the United States. Well-defined blackened areas occur on the tip and sides of the fruit and affected tissues have a somewhat bitter taste. Black scald does not seem to be related to blacknose.

AL-WIJAM

Al-Wijam is a minor date palm disease of unknown cause in Saudi Arabia, according to Nixon (60). Affected trees are stunted, become unfruitful, and eventually die. The only unique symptom is "a faint, narrow, yellow, longitudinal line" on the midribs of the younger leaves. The decline occurs in plantings whether conditions for growth and fruiting are favorable or unfavorable.

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ACCIDENT PREVENTION IN THE DATE INDUSTRY

By W. G. KENNEDY — SAFETY ENGINEER

State Compensation Insurance Fund

When material on this subject was prepared for the Institute of April 28, 1956, the Industry was in a serious predicament in connection with workmen's compensation insurance coverage due to the poor accident and injury record.

The poor record, types and numbers of accidents, accident causes, corrective measures, workmen's compensation insurance, progress of the new Safety Program, equipment changes, and numerous other details which most of you know were recorded in that material and, in general, need not be repeated.

To quote the last three paragraphs:

"The material presented thus far has been given in an effort to show that continuing action is necessary and that only cooperative effort and close supervision and attention by management can keep accident prevention ahead of the growth of the palms and in step with efforts toward improving the industry."

"With this in mind, the State Compensation Insurance Fund, through its Safety Services, has discussed the problems and proven safe practices and equipment with each Fund insured. In addition, a meeting of those employers and their supervisors is to be held in a convenient date garden for a discussion of details of future safety activities, including actual demonstrations of equipment and methods which have been found to be practical and safe. Others who may desire to participate will be more than welcome."

"The program resulting from this meeting and future activities will apply to all Fund insureds. It will be for the benefit of all concerned and its effectiveness will depend on the ideas and efforts of individual supervisory personnel and employees. Assistance will be continued by Fund safety personnel."

Work had already been done toward a program for correcting the conditions and more followed, including the "meeting of employers and supervisors". You and many others outside of the area know the results.

Within four years after the State Fund assumed the almost exclusive compensation insurance coverage of date producing and handling, the surcharge rate originally assessed was removed, and the normal orchard rates have applied since that time.

This was the result of the best cooperative accident prevention effort I have known.

During the years of this Accident Prevention Program there was in existence an Electrical Safety Order of the Division of Industrial Safety setting forth conditions for operating equipment and working near high-voltage lines, but little was done to remove the possibility of electrical injuries.

Management, supervision, cooperative employees, Bulletins, personnel and the Safety Committee of the Coachella Valley Farmers Association kept things running smoothly even though there may have been technical violations of the Safety Order when aluminum ladders, dusters and other equipment were in use.

Then the smoothly running machine was given some inferior fuel; workers, supervisors and employers were disturbed; things began to sputter and four accidental deaths by electrocution were recorded in a very short time.

At this time the Safety Order for Preventing Accidents in the Area of High-Voltage Lines was published as a part of the new Construction Safety Orders (which also apply to Agriculture and other industries).

The Order reads in part as follows:

"1768. PROVISIONS FOR PREVENTING ACCIDENTS IN THE AREA OF HIGH-VOLTAGE LINES. (a) GENERAL. No person, firm, or corporation, or agent of same, shall require or permit any employee to perform any function in proximity to high-voltage lines; . . . . . unless and until danger from accidental contact with said high-voltage lines has been effectively guarded against in the manner hereinafter prescribed."

"(b) CLEARANCE OF SAFEGUARDS REQUIRED. The operation, erection, or transportation of any tools, machinery, or equipment, or any part thereof capable of vertical, lateral, or swinging motion; the handling, transportation, or storage of any supplies, materials or apparatus; or the moving of any house or other building, or any parts thereof, under, over, by, or near high-voltage lines, is hereby expressly prohibited, if at any time during such operation, transportation, or other manipulation it is possible to bring such equipment, tools, materials, building, or any part thereof within 6 feet of such high-voltage lines, except, however, that when such high-voltage lines have been effectively

guarded against danger from accidental contact, either by:

(1) The erection of mechanical barriers to prevent physical contact with high-voltage conductors;

(2) De-energizing of the high-voltage conductors and grounding where necessary;

(3) Removal of the high-voltage conductors; . . . ."

"(c) WARNING SIGNS REQUIRED. The owner, agent, or employer responsible for the operations of equipment shall post and maintain in plain view of the operator on each crane, derrick, power shovel, drilling rig, hay loader, hay stacker, pile driver, or similar apparatus, any part of which is capable of vertical, lateral, or swinging motion, a durable warning sign legible at 12 feet reading: 'UNLAWFUL TO OPERATE THIS EQUIPMENT WITHIN 6 FEET OF HIGH-VOLTAGE LINES', also a sign with letters of similar size reading: 'ALL EQUIPMENT SHALL BE SO POSITIONED, EQUIPPED, OR PROTECTED SO THAT NO PART SHALL BE CAPABLE OF COMING WITHIN 6 FEET OF HIGH-VOLTAGE LINES.' "

The use of the second sign or warning is new.

High-voltage Circuit is defined as "Any circuit having a difference of potential of more than 600 volts (750 volts where specified in certain orders) between any two conductors of the circuit", but we must not forget that there is danger from voltages much lower than this.

Representatives of the Division of Industrial Safety have left no doubt that this Construction Safety Order will be enforced in agriculture.

It must also be remembered that should an injury or death result from a violation of the conditions of this Order known to employer and/or his supervisors, the employer may be assessed an uninsurable penalty for serious and willful misconduct amounting to 50% of the compensation paid on the claim up to $7,500. Serious and willful misconduct on the part of the injured employee may cause the compensation to be reduced one-half.

Following the first of the four electrical fatalities which involved the handling of an aluminum ladder, investigation and discussion of ways and means of prevention were started.

Bulletin No. 2, as shown below, was issued by your Association after the Requirements were reviewed by the Safety Committee and others.

COACHELLA VALLEY FARMERS ASSOCIATION

P.O. Box 845 Thermal, California

BULLETIN No. 2 February 11, 1966

TO: ALL MEMBERS

SUBJECT: ELECTRICAL SAFETY REQUIREMENTS

The Safety Engineer of the State Workman's Compensation Insurance Fund has drawn up the following safety precautions and all growers are urged to see that these rules are enforced on their farms.

Safety Precautions—Date Garden & Other Work

General

1. Do not operate machines, ladders or other equipment so that any part is within 6 feet of High Voltage electric power lines or other high voltage source of electric power.
2. All machines and similar equipment shall be properly posted with warning signs.
3. Instruct all employees regarding the hazards of high voltage lines.
4. Tell all personnel that in case of accidental contact of metal parts with power lines they must *stay on the equipment* or *jump* to the ground without holding or touching any part of the equipment. Be sure that this is understood.

Dusters

Work is in progress on safety precautions for dusters and will be released within a short time. In this connection experiments are being carried out with plastic tubes.

Towers or Lifts

1. Observe all precautions listed under *General*.
2. Do not ground metal parts.

Ladders

1. Equip all palms adjacent to power lines with permanent ladders to within eighteen feet of the ground. They should be on the side away from the power lines.
2. Do not use any metal ladder longer than twenty feet on any palm adjacent to power lines.
3. Do not permit metal ladders longer than twenty feet to be moved or handled under power lines or beyond the row adjacent to them.
4. Observe precautions listed in (1) and (3) of general instructions.

Very truly yours,

COACHELLA VALLEY FARMERS ASSN.

LELAND J. YOST,
General Manager

LJY/sm

The work on dusters has progressed through discussions with electrical engineers, representatives of duster manufacturers, material manufacturers and members of your own group.

Samples of plastic tubing were sent to the Valley by a manufacturer.

A meeting of growers and supervisors, similar to the one of ten years ago, was held at the Farmers Association for inspection and discussion of the tubing and ways and means of using it.

Specifications and prices were supplied by the manufacturer and provisions were made for assembling orders and purchase of the materials.

Use of the plastic tubing poses a problem of dissipation of static electrical charges generated by flow of the dusts, but several suggestions have already been made for handling this.

A system of grounding the blower rotor to the frame will also be worked out. With this done, a chain or other grounding device should eliminate the sulphur fires.

There will be no shocks from static under normal conditions since the tubing will not conduct the charge.

The plastic tubing will not conduct electricity when or if subjected to voltages far above the highest in use in the area.

It will be necessary to provide storage, preferably in the shade, with sufficient support to prevent bending or warping due to heat.

With reasonable care the tubing should last many years without denting or breaking.

Supervision and training will continue to be the key to success even more than in recent years. Accidents can and will be held to a minimum if all remember to

MAKE ACCIDENT PREVENTION A PART OF EVERY JOB

GERMINATION OF DATE POLLEN IN CULTURE MEDIA

By J. R. FURR and V. M. ENRIQUEZ

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Introduction

Since date pollen is often stored from one season to the next, a test for viability before and after storage may be advisable. Germination *in vitro* has been used for over 20 years as a test of viability. In the past 15 years we have tried several germinating media and indirect tests of vitality, e.g., staining by tetrazolium chloride or acetocarmin, but until recently our standard procedure was to observe germination of pollen sown on a hanging drop in a Van Tieghem cell. This method was, however, laborious and often yielded highly erratic results. When making germination tests recently on many lots of pollen being used by others in tests of pollen application by helicopter and aeroplane, we realized that an easier, more reliable, and faster method of germination was urgently needed. This paper reports our search for such an improved method.

Literature Review

The literature on germination of pollen in artificial media and, in recent years, on pollen physiology is large. Linskens (8) reviewed recent work on pollen physiology and biochemistry and edited (9) the proceedings of an international symposium on pollen physiology and fertilization.

Little work has been done on date pollen germination and physiology. Consequently, methods used on dates were adapted from work on pollen of other plants. Early European workers discovered that pollen of many species can be germinated in artificial cultures and that sugar, oxygen, and a moist medium are essential for good germination and pollen tube growth of many species. Sandsten (15) and Brink (4) found that many pollens would germinate over a wide range of sugar concentration in the culture medium, and that sucrose gave as good results as any of the several sugars tried. Brink (4) tested the effect of many salts, organic compounds, and plant extracts. He obtained improvement in pollen germination and tube growth from addition of yeast extract, raw potato juice, or extracts of flower parts to the medium used. He also observed the *population effect*, i.e., that germination was better if pollen was sown thickly in the culture than if there were relatively few widely scattered grains in the medium.

Schmucker (16) discovered that small amounts of boron added to culture media greatly improved pollen germination and tube growth.The first application of Schmucker's discovery to pollen physiology in this country was that of Cooper (5), who found that boron influenced the germination of papaya pollen.

Batjer and Thompson (2) increased the set of pears by spraying the flowers with a solution of boric acid, and Thompson and Batjer (18) obtained marked improvement in germination and tube growth of pollen of several tree fruits by adding 2.5 to 40 ppm of boron to 10% sucrose germinating medium.

Gouch and Dugger (7), and Vasil (19) reviewed and discussed recent work on the physiological effects of boron on pollen. It is now clear that pollen is often deficient in boron and that germination and tube growth of most kinds of pollen are improved by addition of boron to the germinating medium. Although several theories to account for the effect of boron on pollen germination and tube growth have been proposed, its specific function is not definitely known (7, 19).

Brewbaker and Kwack (3) recently discovered that in the presence of boron and potassium or magnesium ions, calcium salts produced marked improvement in pollen germination and tube growth of a large number of plant species. They observed that calcium ions in the germinating medium eliminated the *population effect* and growing tubes were straight and did not bend toward groups of pollen grains in the germinating medium, as usually occurred in media without calcium salts. Recent evidence (11) indicates that in the process of fertilization the growth of the pollen tube is directed "chemotropically" through the stigma, style, and ovary by a calcium gradient to the ovule, which has a higher calcium content than any other part of the pistil.

Loo and Hwang (10) improved pollen germination and tube growth by addition of manganese sulphate to sugar culture solution, and Zielinski and Olez (20) reported similar results with prune and pear pollen from the addition of 12.5 ppm of chelated manganese to a medium containing sucrose and yeast extract.

Smith (17) observed that pollen of several species germinated in sugar-agar medium produced pollen tubes of increasing thickness as the temperature of the medium was raised. The optimum temperature for snapdragon pollen was 25 C; at 30 C the pollen tubes bloated; at 35 C extensive bursting of bloated tubes occurred.

In an early study of date pollen viability and germinating in artificial media, Albert (1) first tried a sterile medium of 10% sucrose in 1% agar in Petri dishes. He found the preparation of this medium laborious and observation of the pollen under the microscope difficult, and consequently he settled upon a hanging drop culture of 20% sucrose. The latter method was a distinct improvement but he still obtained variable results. After heating date pollen for various periods, Gerard (6) determined its viability by germination tests in hanging drops of sugar solution. The percentage of germination steadily decreased with increasing time of heating, but low percentages germinated after 75 min at 140 F. Monciero (12) sowed date pollen on a medium of 2% glucose and 1% agar in Petri dishes, incubated the cultures 24 hours at 27 C, and then killed the pollen with formalin. He found great variability in the percentage of germination of pollen from different males and from different inflorescences from the same tree. Pollen from inflorescences that emerged very early or very late in the season had poorer germination than pollen from midseason inflorescences. Pereau-Leroy (14) found the germination of date pollen in sugar-agar medium an unsatisfactory measure of viability, and he considered instead the staining of date pollen with acetocarmin to be the best laboratory test of its viability. He observed that samples of viable pollen

contained few non-staining, empty grains. The viable grains stained red and were spherical and of regular shape. In recent work in Israel, Oppenheimer and Reuveni (13) obtained consistent and reliable results in date pollen germination tests by suspending 100 mg of pollen in 50 ml of an aerated solution consisting of sugar and boric acid in distilled water, and held in a measuring cylinder in a water bath at 86 F. The sucrose content of the medium was not critical, 10 to 15% being satisfactory, but with increasing boric acid content up to 500 ppm, germination improved.

Germination tests and results

We tried several methods of germination *in vitro*. In the first method, the medium was 10 to 20% sucrose and 1% agar, made up in distilled water. The pollen was sown on a drop of medium on a microscope slide. Several slides were placed in a Petri dish containing moist filter paper to prevent drying of the medium. The results were extremely erratic; often repeated trials were made before we could determine the approximate percentage of viable grains.

Hanging drop cultures in Van Tieghem cells produced much more reliable results, and this method was used on both date and citrus pollen until recently. Through its simultaneous use for germination of several kinds of pollen, we discovered that date pollen does not germinate *in vitro* as readily as pollens of citrus and some citrus relatives. At first, a solution of 10 to 20% sucrose in distilled water was used. After tests in 1951 showed that the addition of boron increased germination and reduced bursting of the pollen tubes, boric acid, 300 to 500 ppm, was added. Hanging drop cultures were prepared by sealing a glass ring to the slide with vaseline, sowing pollen on a drop of culture medium on a cover slip, then sealing the cover slip (drop down) on the upper edge of the ring with vaseline. Before the cover slip was sealed onto the ring several drops of culture medium were placed in the ring to prevent drying of the hanging drop. Sometimes a culture was lost because of poor sealing of cover slip to ring, or because the hanging drop would run down the side of the ring. Preparing the cultures and cleaning the slides and rings was tedious and time-consuming; consequently, we tried the tetrazolium chloride test for viability of pollen and staining with acetocarmin. By neither method could we distinguish between viable and dead pollen, and hanging drop cultures were continued until 1966, when we made an intensive study of methods to improve speed and reliability of the germination test.

We had long been plagued by erratic germination and such abnormal behavior of the pollen as bursting of the grains or tubes, swellings along the tube or at the tip, or crooked growth of tubes, and slow germination. We tried media containing various substances reported to improve germination or tube growth of other kinds of pollen and found in some tests benefits from yeast extract, water extract of date pollen, coconut milk, juice from date pistils, and stigmatic fluid applied to the cover slip to which the medium was applied. None of these substances, however was consistently and distinctly beneficial. Some caused difficulties in observing the pollen for germination counts, and we stopped using them after trying the following solution which Brewbaker and Kwack (3) recommended for most kinds of pollen:

10% sucrose,
100 ppm H_3BO_3,
300 ppm $CaNO_3 \cdot 4H_2O$,
200 ppm $MgSO_4 \cdot 7H_2O$,
100 ppm KNO_3,
made up in distilled water.

In this culture medium the rate and the percentage of date pollen germination were improved, the tubes were relatively straight and free from swellings, and bursting of grains and tubes was greatly reduced. We had previously found that bursting of pollen grains or tubes was somewhat less in 15 to 25% sucrose solution than in 10% solution, and that the percentage of germination was slightly higher in solutions containing 300 to 500 ppm of boric acid than in those of lower or higher concentrations (Table 1). Consequently, we adopted as the standard medium a modified Brewbaker and Kwack (MBK) solution containing 15% sucrose and 500 ppm of boric acid, but with the concentration of the salts unchanged. Tests showed that, as with most other kinds of pollen, the sugar concentration was not critical. We found, for example, that varying the sugar concentration in the MBK solution from 10 to 20% did not significantly affect the percentage of germination (Table 2).

Table 1. Influence of boron concentration in sucrose medium and modified Brewbaker and Kwack medium on germination of date pollen

Medium and Pollen no.	Boric acid (ppm)	Germination (%)
20% sucrose medium		
Pollen P-1	0	40
	29	75
	57	77
	143	64
	285	85
	571	84
	Saturated	0
MBK medium[1]		
Pollen C-13	100	0
	300	74
	500	77
	1000	71
Pollen D-16	100	0
	300	33
	500	47
	1000	21

1 MBK=modified Brewbaker and Kwack medium which is: in distilled water, 15% sucrose, 500 ppm H_3BO_3, 300 ppm $CaNO_3 \cdot 4H_2O$, 200 ppm $MgSO_4 \cdot 7H_2O$, 100 ppm KNO_3.

Table 2. Influence of sugar concentration in the medium[1] on percentage germination of date pollen

Sample no.	Sucrose concentration[2] 10%	15%	20%
Ru 2	74	74	58
D 13	70	77	76
D 14	68	80	85
Av.	71	77	73

1 Medium – MBK
2 Sucrose concentration – weight/volume per cent

The work of Oppenheimer and Reuveni (13) suggested that more uniform and reliable results might be obtained with relatively large amounts of pollen in large volumes of culture solution than in single drop cultures. We used the same proportion of pollen to solution they used, i.e., 100 mg pollen in 50 ml of culture solution, but instead of aerating a deep column of culture solution we poured just enough MBK medium containing pollen into a 125 ml Erlenmeyer flask to barely cover the bottom so that oxygen could diffuse rapidly through the thin layer of solution. Germination was excellent in these flasks. Trials were run with stoppered and unstoppered flasks, and with stoppered flasks in which the air was enriched by a few ml of pure oxygen. Enrichment of the air by O_2 apparently improved germination slightly, but not enough to justify devising a method of treating the cultures with enriched air of uniform oxygen content, since we wished to use the simplest satisfactory method that could be devised.

Germination in Van Tieghem cells and flasks did not differ significantly. Germination in flasks was also as good as in Petri dishes or pint plastic cups containing just enough culture solution to barely cover the bottoms. To determine whether oxygen supply and thereby pollen germination in flasks might be influenced by small variations in depth of the cultures, pollen was germinated in 1, 2, or 3 ml of solution (Table 3). MBK medium was used except that in one set the medium contained 10% sucrose. Depth of solution or depth of the pollen in the solution at sowing did not affect germination. In some cultures pollen was sown on the surface of the solution; in others the flask was shaken until the pollen was wetted and suspended in the solution. Germination was nearly inhibited, however, by poor oxygen supply in flasks containing 30 to 40 ml of culture solution. A few grains, presumably those near the surface, showed slight extension of the pollen tube,

Table 3. Influence of depth of date pollen in culture medium on germination

Treatment of pollen	Sucrose concentration	Volume[1] medium	Germination
	(%)	(ml)	(%)
Sown on surface of medium	15	1	88
		2	86
		3	80
Suspended in medium	15	1	79
		2	82
		3	82
	10	1	89
		2	82
		3	84

1 Volume of MBK culture medium in 125 ml Erlenmeyer flasks

indicating that germination started but was stopped, probably by oxygen deficiency. Germination seemed to be the same in stoppered and unstoppered flasks containing 1 to 5 ml solution.

To examine pollen germinated in a flask, one or two drops of the culture solution containing the pollen were placed on a microscope slide, a cover glass was placed on each drop to give a flat field, and the pollen was examined under low power (100 X) of the microscope. The counts of pollen grains to determine germination percentage could be made more rapidly and easily on slides with a flat field than on the hanging drops in Van Tieghem cells, and any number of slides needed could be prepared from the large volume of culture solution in a flask.

Before adopting MBK medium, we sometimes obtained high percentages of germination in solutions of sucrose and boric acid. To determine whether germination in MBK solution was better than in sucrose and boric acid solution, we germinated subsamples from the same pollen sample in MBK medium and in a solution of 15% sucrose and 500 ppm of H_3BO_3 in distilled water. Mean germination in the MBK medium was 70.4% and in the sucrose and boric acid medium, 53.8%. The difference was highly significant.

Pollen samples received for testing are frequently mixtures from genetically different males, so that extreme variability may be expected in

Table 4. Variation in percentage of germination of date pollen with time in the culture medium at 73 to 76 F

Sample no.	Time (hours:minutes) 2:00	2:25	2:40	24:00
	(%)	(%)	(%)	(%)
Co 1	35	40	46	62
Co 2	25	33	38	54

percentage of germination and growth of the pollen tubes. To estimate the variability to be expected in samples of relatively uniform pollen, a sample from a single inflorescence was dried and thoroughly mixed and 10 subsamples were germinated in flasks in MBK medium. From each flask 3 slides were prepared and 100 grains of pollen on each counted. Germination of pollen on the 30 slides varied from 60 to 90% and the mean was 78.2%; the mean of flasks 1 to 5 was 80.5%; the mean of flasks 6 to 10 was 75.9%. The average germination percentages of pollen from 12 males from 8 different breeding lines were as follows: 20, 10, 56, 0, 65, 60, 44, 70, 0, 70, 60, 40. The viability of pollen from these males was doubtless far below the average because some were produced by inbreeding and some were flowering for the first time.

The time required for germination of different pollen grains within a sample varied considerably (Table 4); but in a favorable medium and at favorable temperatures (75 to 85 F) nearly all the viable pollen germinated within 24 hours, and usually the major part of it within 4 hours.

Though temperatures above 100 F favor growth of fruit and leaves of the date, the pollen germinated nearly as quickly at 76 to 80 F (room temperature) as at 92 to 94 F (incubator temperature). The average germination in 10 flasks under each condition was as follows: at 76 to 80 F— after 3 hours 62%, after 24 hours 68%; at 92 to 94 F— after 3 hours 67%, after 24 hours 61%. Pollen held at 92 to 94 F for 24 hours had many burst or swollen tubes, apparently a result of high temperature.

A comparison of germination and tube growth of pollen from the same sample was made in 5 subsamples in two different media at two temperature ranges. After 2-½ hours in MBK medium 55 to 65% of the pollen had germinated and tubes were straight and normal at both temperature ranges: 92 to 94 F and 78 to 80 F. After 2-½ hours in 15% sucrose in distilled water the pollen had produced no normal pollen tubes: at 92 to 94 F, 37% of the pollen grains had burst; at 78 to 80 F a few grains were germinating and 60% of the pollen had ruptured.

Several tests were made to determine the influence of chelated manganese (Na_2Mn) on germination of date pollen. When 12 ppm of Na_2Mn was added to MBK medium and to a solution of 15% sucrose in distilled water, germination was significantly better than in the same media without Na_2Mn; but in two other tests in which 12 and 24 ppm of Na_2Mn was added to MBK medium, percentage of germination was not significantly better than in MBK medium, though tube growth was somewhat better. The improvement effected by 12ppm of Na_2Mn in MBK medium, though small, probably justifies its inclusion in a standard medium for germinating date pollen.

Since some salts are desirable in the culture medium, trials of two different media made up with water from two artesian wells were carried out. Though these waters are low in salts, the specific electrical conductance (K X 10^5 at 25 C) being about 32, they contain something that greatly reduces germination and causes the pollen grains and tubes to burst. Germination of pollen in MBK medium made up with these waters was 21 and 22% as compared with 66% germination in MBK medium made up with distilled water. In media made up with well water 39 to 44% of the pollen burst, but in the media made up with distilled water no bursting was observed. No effort was made to identify the harmful substance in the well waters, though it may be traces of lubricating oil, a layer of which covers the water in the wells.

To learn approximately how long pollen will remain viable after it has been placed in the inflorescences in the usual manner of pollinating we put cotton balls containing pollen in inflorescences at appropriate time intervals and removed some each week

Table 5. Loss of viability of pollen held in cotton balls in the tree compared to that of pollen held in refrigeration[1]

Date tested	Percentage germination[2] Number of days in tree: 7	14	21	28	35	42	49	56	Control in refrigerator
1951									
Apr. 5	59								54
12	65	74							54
19	46	41	41						45
26[3]	32	40	39	25					21
May 3	69	63	63	47	62				67
10				—	48	10			26
24				8	0.2	20	10	5	12
Av.	54.2	54.5	47.6	26.7	36.7	15	10	5	39.9

1 Medium used was 20% sucrose, 300 ppm H_3BO_3.
2 % germination—average of 5 slides.
3 Rain (0.16 inch) occurred 2 to 6 p.m. April 25.

for germination tests. A control sample of pollen was kept in the refrigerator. The results of the germination tests (Table 5) indicated only slight loss of viability during the first 4 or 5 weeks. These tests were run before we began using MBK medium so that the results were highly erratic. Rain (0.16 inches) on April 25 did little damage to the pollen in the cotton balls in the tree.

Discussion and Conclusions

Our experience with pollens of citrus and citrus relatives, using the same methods and media as with date pollen, indicates that the latter is especially sensitive to unfavorable conditions for germination and growth of pollen tubes. Compared to citrus pollen, date pollen germinates relatively slowly and unfavorable media or temperature more readily produce abnormalities like bursting of the grain or tube and loss of contents, swelling of the tube, or growth of crooked tubes. Since the vitality of date pollen that has been in storage for a long time or under unfavorable conditions of moisture or temperature may be rather low, a favorable medium for germination *in vitro* is essential to evaluate its usefulness for pollination. Germination of date pollen is probably better *in vivo* than *in vitro* in the best medium we know how to prepare. Some growth factors may still be missing. However, quick, practical, and reliable results may be obtained by sowing pollen in modified Brewbaker and Kwack medium and incubating it in 125 ml Erlenmeyer flasks or any other similar vessel at ordinary room tempertures of 75 to 80 F. Since there was some benefit from chelated manganese (Na_2Mn), we recommend that 12 ppm be included in the medium. It is convenient to prepare stock solution in fairly large quantities containing all of the chemicals except the sugar. Since the amount of sugar is not critical, it can be measured by volume to provide approximately 15% by weight to make up small amounts of germinating medium as needed. For example ,the sugar can be measured with sufficient accuracy in a graduated cylinder if it is tapped to settle the grains to a close fit; e.g., in a 50 ml cylinder about 16 or 17 ml of ordinary granulated sucrose weighs about 15 g, the amount needed for 100 ml of medium. The stock solution for germination of date pollen may be made up with the following per liter of distilled or deionized water:

H_3BO_3	0.5 grams
$Ca(NO_3)_2 \cdot 4H_2O$	0.3 grams
$MgSO_4$	0.2 grams
KNO_3	0.1 grams
Na_2Mn[1]	0.1 grams

To this solution add 10 to 20% sucrose.

[1] Active ingredient of manganese chelate: technical disodium manganous ethlenediamine tetraacetate dihydrate. 0.1g of 12% chelated manganese per liter = 12 ppm of Mn.

Abstract

Germination trials of date pollen were made in a search for a rapid and reliable method of testing its viability. Pollen sown on a drop of medium of sucrose or sucrose and agar on a slide and incubated in humid air gave erratic results. Much of the pollen burst or produced abnormal tubes. Sowing pollen on drops of medium in Van Tieghem cells and the addition of boric acid to the sugar medium improved germination and reduced bursting of pollen, but this method was tedious and not fully reliable. A rapid and reliable method that produced excellent and fast germination, normal pollen tube growth, and almost no bursting of pollen grains was the germination of pollen in 3 to 5 ml of modified Brewbaker and Kwack (MBK) medium in 125 ml Erlenmeyer flasks at 75 to 80 F. MBK medium was prepared by adding 15% sucrose to a stock solution composed of 0.5g H_3BO_3, 0.3g $Ca(NO_3)_2 \cdot 4H_2O$, 0.2g $MgSO_4$, 0.1g KNO_3, 0.1g Na_2Mn in 1 liter of distilled water.

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POLLINATION OF DATES BY FIXED-WING AIRCRAFT

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I made the first attempt to pollinate dates by means of a fixed-wing aircraft in 1963. Pollen diluted with ground walnut hulls and wheat flour was applied to palms at weekly intervals during the period when inflorescences were opening (1). Estimates indicated that about 44% of the fruit that set had been pollinated. Ground walnut-hulls and wheat flour proved equally satisfactory as pollen diluents. The most effective pollination was in midseason and the low percentages of pollinated fruit were on the early and the late bunches.

In 1964 a combination of pollination by hand and by air yielded erratic results. Many of the bunches pollinated by hand had lower percentages of pollinated fruit than those pollinated by air. Possibly, some of the inflorescences pollinated by hand had already passed the stage of receptivity when they were pollinated (2).

In 1965 the frequency of applications of pollen was increased to twice weekly, except that bad weather caused a 7-day interval between the first and second applications. Applications were made in the mornings of the following dates: April 6, 13, 16, 20, 23, 27, 30, May 4, 7, 11. To maintain the schedule, flights were sometimes made in weather too windy to be considered suitable for dusting. In 1965 pollen was diluted with wheat flour: 1.5 quarts to 15 pounds of flour.

An experienced date worker evaluated the results of the tests and, at the time the fruit was changing from green to khalal color, estimated the percentages of pollinated fruit. The range in percentage of pollinated fruit estimated per bunch was 0 to 100%; the average was 65.8% a gain of 26.7% over the previous year. The bunches representing the extremes of low or high percentages of pollinated fruit were randomly distributed over the garden. From a block of 7 acres pollinated, the fruit was harvested by hand, amounting in 1964 to 28,493 pounds and in 1965 to 35,583 pounds. This does not include field culls which, in 1965, were estimated at about 3,000 pounds. The fruit in 1964 and 1965 was harvested by hand. The grades of fruit harvested in 1965 were as follows: high moist and B—21,041 lb., C—11,492 lb., plant culls—3,050 lb. The total amount graded was 35,583 lb.

The results of this test did not show that a higher percentage of fruit could be pollinated by pollinating twice a week instead of once a week. It is also not clear whether an acceptable percentage of pollinated fruit can be obtained by pollinating with a fixed-wing aircraft.

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POLLINATION RESEARCH DISCUSSION

By G. K. BROWN

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In February, 1965, the Date Administrative Committee asked the U.S. Department of Agriculture and University of California to assist the date industry in developing more efficient methods of pollinating. Pollination season was starting and neither personnel nor funds were immediately available to carry on a complete research program. Time studies (1) previously had shown that pollination required more labor than any other operation except hand picking. Observations were made, information gathered, and labor aids investigated. During 1965, the Date Administrative Committee was successful in obtaining a Federal appropriation to support engineering research on pollination methods and equipment. The Agricultural Engineering Department, University of California, Riverside, and U. S. Date and Citrus Station, Indio, are working with us on this project.

It was decided to investigate two approaches to the problem to start with. The first was to try to develop a tool which a man could use to rapidly open the spathe and pollinate the inflorescence without entering the palm, that is, possibly while standing on a harvesting platform. At this time, we have not been able to show an increase in efficiency with such a tool. Because of the close quarters and many limbs near the crown of the palm, it is easier and faster for a man to enter the palm and pollinate by one of the methods now used.

The second approach was to use fixed-wing aircraft for applying pollen, as previously reported by Mr. Preston (2), (3), and to initiate a rotary-wing (helicopter) aircraft program.

Both aircraft programs are now in operation. Twelve growers have volunteered 40 palms each to this year's aerial pollination program. The aerial application rates and frequencies are:

HELICOPTER

No. of plots	Application Interval (days)	Application Rate Qt/Acre	Pollen/ Acre/ Season
2	2	1/24	1 quart
2	4	1/12	1 quart
2	2	1/8	3 quarts
2	4	1/4	3 quarts

FIXED-WING

2	2	1/8	3 quarts
2	4	1/8	1½ quarts

For these tests, it is assumed that each garden will be flown for 7 to 8 weeks.

Several growers' records show that about 1 quart per acre of dried pollen is normally applied by hand pollinators when cotton balls and dusters are used. The fixed-wing applications are a mixture of about 10% pollen and 90% bleached wheat flour, so that the normal metering and crop dusting equipment can be used. The helicopter applications are pure pollen, which is metered and distributed with specially designed equipment. Each aircraft applies pollen to two rows of palms at each pass.

Vaseline coated slides are placed in some palms to catch a sample of the pollen applied on each flight. The success of any pollination method depends on the resulting crop; so the results of this work cannot be accurately reported until next year. The yield from all test plots will be recorded and compared to yield of hand-pollinated palms nearby.

Aerial pollination probably will not eliminate the necessity to thin and tie the strands up to prevent entanglement in the fronds and fruit scarring. If successful, it will remove the peak from the labor requirements at pollination time and spread the work for tie-up and thinning over a longer period of time.

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P

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Peter Rabbit Farms, Box 96 ..... Coachella
Pierson, Rollins, 7845 Torreyson Dr. ..... Los Angeles
Pinkley, Virgil M., P.O. Drawer NNN ..... Indio
Pinyan, R. A. & Margaret, 81-710 Miles Ave. ..... Indio
Pollock, Harry C., 300 Lincoln Bldg. ..... Cleveland, Ohio
Portola Ranch, Box 833 ..... Indio
Prairie Ave. Gospel Center, c/o Carl Pike,
13600 S. Prairie Ave. ..... Hawthorne
Preston, Richard D.
17656 Santa Teresa ..... Fountain Valley
Pryor, Anna K., P.O. Box 157 ..... Rancho Mirage
Pulus, J. H. Ranch, 72-789 Bel Air Rd. ..... Palm Desert

R

Rancho Del Rey, Box 833 ..... Indio
Rancho Ramona, c/o Harboe Mng. Serv.,
P.O. Drawer 1787 ..... Indio
Rancho Sonora, c/o Harboe Mng. Serv.,
P.O. Drawer 1787 ..... Indio
Rapkin, Joseph, 735 N. Water St. ..... Milwaukee, Wisc.
Rémy, R. H., Apartado postal 22,
Saltillo ..... Coahuila, Mexico
Reuther, Walter, Dept. of Hort. Science,
U. of Calif. ..... Riverside
Richardson, H. B., Hort. Science Bldg.,
U. of Calif. ..... Davis
Riverside Co. Agric. Commissioner,
4060 Orange St. ..... Riverside
Robinson, Donald, 45-251 Palm Dr. ..... Indio
Rogers, David A., Route 1, Box 271 ..... Winterhaven
Rudd, Will D., 713 Rosecrans St. ..... San Diego
Rummonds Bros., Box 726 ..... Thermal
Rutherford, Paul, Route 1, Box 73 ..... Coachella
Rygg, G. L., Box 700 ..... Pomona

S

S. & G. Ranch—G. K. Ranney,
11712 Lampson Ave. ..... Garden Grove
Schmid, Dorothy, Route 1, Box 35 ..... Coachella
Schmid, Henry M., Route 1, Box 35 ..... Coachella
Schmid, Thomas, Route 1, Box 35 ..... Coachella
Schmid, Walter, 7931 Lampson Ave. ..... Garden Grove
Schuman Co., 404 N. Roxbury Dr.,
Suite 815 ..... Beverly Hills
Schwartzburd, Martin, 11509 Duque Dr. ..... Studio City
Shearer, S. K., 511 Toyopa Dr. ..... Pacific Palisades
Sieman, Fred, Box 44 ..... Palm Desert
Smart, Jackson W., 208 S. La Salle St. ..... Chicago
Smead, Paul, P.O. Box 3921,
Frere Hall ..... Karachi, Pakistan
Smigel, George B., 2017 Granville ..... Los Angeles
Snow, Dr. Rodney H., 301-20th St. ..... Santa Monica
Soloro Ranch—G. H. Leach, Route 2, Box 115 .... Thermal
Stock, Edward & Pat, Route 1, Box 720 ..... Thermal
Strehle, Joseph, 1338-21st St. ..... Longview, Wash.
Swingle, Mrs. Walter T., 2241 Durant Ave.,
Apt. 15 ..... Berkeley

T

Tall Palms Ranch—D. Mitchell, Box 833 ..... Indio
Thielemeir, Lawrence G., Box 265 ..... Santa Ana

U

Urick, W. E. Ranch, 5142 Los Diegos Way .... Los Angeles
U. S. Date & Citrus Station, 44-455 Clinton St. .... Indio

V

Valley Center Ranch,
75475 Desert Park Dr. ..... Palm Desert

W

Waggoner Bros., Route 1, Box 190 D ..... Thermal
Ward, Edith E., 73-661 Highway 111 ..... Palm Desert
Waters, Norman A.,
3240 Lakeshore Dr. ..... Chicago, Illnois
Webb Farms, Inc., Route 2, Box 68 ..... Thermal
Webb, Robert W. Jr., 8 Warm Sands Pl. ..... Palm Springs
Weiner, Dr. Aaron, Box 638 ..... Indio
Westerfield, James P., Box 595 ..... Mecca
Wilson, Gwynn, 75075 Highway 111 ..... Palm Desert
Wisenant, J. B., 83-977 Highway 99 ..... Indio

Y

Yost, Leland J., Route 2, Box 124 ..... Thermal
Young, Dr. Forrest O., 460 Marion Rd. ..... Redlands

Z

Zarakov, Stanlev & Selma—Cinco Acres,
1630 S. Calle Marcus ..... Palm Springs